Locomobile Type "E" Standard. 20 Horse-power. Price $2900 with Standard Equipment. Top Extra. Price of Chassis with Standard Equipment, $2650. Color scheme, light red with red upholstery

VOLUME ONE

The AMERICAN CYCLOPEDIA of the AUTOMOBILE

or, MOTOR CARS and MOTORING SELF-TAUGHT

A WORK OF REFERENCE & SELF INSTRUCTION, COVERING the ENTIRE FIELD OF AUTOMOBILING. FOR OWNERS, REPAIR MEN, OPERATORS, INTENDING PURCHASERS & ALL OTHERS INTERESTED IN MOTORING OR the AUTOMOBILE TRADE

Profusely Illustrated

THE TEXT INCLUDES HUNDREDS of HINTS ON MOTOR & OTHER TROUBLES & THEIR REMEDIES .... ROADSIDE REPAIRS, ETC. STUDY HELPS & a COMPLETE CATECHISM on IMPORTANT SUBJECTS .. A HISTORY of the AUTOMOBILE from Earliest Days

Complete in Six Volumes

.... BY ....

THOMAS H. RUSSELL, LL. B., M. E.

:: AND ::

CHARLES P. ROOT, former Editor of *Motor Age*

Assisted by a Corps of Experts

NEW YORK . . . . THOMPSON & THOMAS . . . . CHICAGO

PREFACE

SINCE the dawn of the twentieth century the Automobile has come into its own as a popular means of locomotion and for the first time in the history of automobiling a complete Cyclopedia of information on all topics connected with this important subject is herewith presented to the interested public.

No work on motor cars at all comparable with this in size or scope has ever appeared on either side of the Atlantic and its practical utility and value will be readily recognized by every unprejudiced reader who scans its pages—most of all by those who give it the closest study.

This Cyclopedia is intended especially for the use and benefit of those who, owning or being interested in motor vehicles, wish to understand their construction and mechanism or to learn the most approved methods of operating them and of effecting repairs when the need arises.

Many an automobile owner knows little about his machine and hence sometimes regards it almost with awe, as a thing of mystery as well as of beauty and power. Such lack of knowledge on the part of motorists can readily be supplied by the volumes of this Cyclopedia. Its scope is the entire field of the Automobile. It covers everything relative to motor cars and motoring, while the plan of the work is such that the information contained between its covers can be readily got at.

Attention is particularly drawn to the completeness of the departments concerning Repairs. All other branches of the subject are treated comprehensively in a similar manner, but many motorists being especially interested in the question of

repairs, the mass of information, hints and "tips" given under such headings as **Repairs and Adjustments, Miscellaneous Roadside Repairs,** etc., will doubtless prove an agreeable surprise.

Any one of the innumerable repair hints contained under the headings referred to, and elsewhere throughout the work, may frequently save the reader more than the cost of this Cyclopedia.

Motorists can teach themselves to know their machines thoroughly and practically by study of these volumes just as easily as any form of knowledge can be acquired by self-teaching.

With this Cyclopedia at his command, no one need hesitate to become the owner of a motor car for fear of inability to master its construction and operation, since every novice in motoring can, by means of these volumes, acquaint himself thoroughly with every detail of his machine and with the methods of driving and maintenance upon which skill and experience have set the seal of approval.

In using the Cyclopedia it is necessary only to refer to the name of the subject on which information is required, and this will be found in its regular alphabetical place; all the subjects being arranged alphabetically like words in a dictionary.

For instance: If information is required on Carbureters, or carbureter troubles, the reader has only to turn to the black letter side-head **Carbureter,** in its alphabetical place under **C,** and he will there find a comprehensive article with appropriate sub-headings, under one or more of which he will find just what he is looking for.

All the various parts of motor car mechanism are each described and graphically illustrated in their proper alphabetical place in like manner, while a very complete system of cross-references in the text materially assists the reader in finding what he wants quickly and surely.

PREFACE.

A series of Study Helps, in the form of Questions and Answers, supplements the information given on the most important subjects connected with automobiling. The Questions and the Answers being printed on separate pages, the reader is enabled, if he wishes, to use the questions for self-examination or review.

The American Cyclopedia of the Automobile is not only the largest work ever published on the subject of motor cars and motoring, but the publishers are confident that it will be found the most complete and most useful; that it will fill a void long felt by motorists, and by those contemplating the purchase of a motor car.

As a work of reference on everything connected with the subject, this Cyclopedia has no rival near its throne. As a helpful guide in time of trouble, it will be found a friend indeed, useful alike to owner, repairman, and driver; and by its aid the owner may become, in most cases of trouble, his own repairman. It was mainly with this object in view that the work was undertaken and is now dedicated to the motoring public.

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BRIEF SYNOPSIS OF SUBJECTS.

VOLUME I.

Accelerators—Acetylene—Adjustments—Advance Sparking Air Bottles—Air Cooling—Alcohol as Fuel for Gas Engines —Ammeters—Amperage—Anti-freezing Solutions—Armature.

Axles Fixed, Floating or Live, etc.—Axle Bearings—Back-firing—Balance or Differential Gear.

Batteries, Primary, Secondary and Storage—Types of Batteries—Charging and Recharging Batteries—Care of Batteries.

Ball Bearings—Roller Bearings—Hot Bearings.

Hints and Instructions for Beginners.

Body Work—Types of Body—Bolts and Nuts.

Brakes and Braking Devices—Brazing—Burners—Brasses —Bushing—Cams and Camshafts—Carbon Deposits and Removing Same—Carborundum.

Carburation and Carbureters—Surface Carbureters—Float-feed Carbureters—The Float Chamber and Spraying Nozzle—Types of Modern Carbureters—Functions and Essential Parts of a Carbureter—The Automatic Auxiliary Air Valve—The Throttle Valve—Quality of the Mixture—Flooding the Carbureter—Carbureter Troubles and Remedies—The Freezing of Carbureters—Choked Carbureters—Care of Automatic Carbureters—Alcohol Carbureters.

Chains—Chain Adjustment—Chain and Gear Drive.

VOLUME II.

Eccentrics—Economizing Gasolene—Economy of Motor Cars—Efficiency—Heat Efficiency—Mechanical Efficiency—"Useful" Efficiency—Efficiency of Battery—The Eisemann Magneto.

Electric Cars—Advantages and Disadvantages of the Electric Motor—Electric Connections, Conductors and Fittings—Elementary Electricity—Comparative Advantages of Electricity, Steam and Gasolene—The Electric Motor—Electrolysis—Electromagnets.

Engines—Engine Flexibility—Engine Troubles and Remedies—Causes of Overheating—Precautions Against Overheating—Removal of Engine Parts.

Explosions in Lamps, Carbureter, Muffler, etc.

Fans—Fat Spark—Fatigue—Fault Finding and Remedies—Feather—Filters—Flanges—Flexible Shaft—Fly Wheel.

Forces—Centrifugal, Electromotive, Magnetic, etc.

Frame—Varieties of Frame Construction—The Question of Rigidity.

Friction—Friction Cones—Friction Drive, etc.

Gasolene—Gasolene Leaks—Gasolene Supply—Fuel Consumption—Fuel Strainers—Gasolene Filters—Gasolene Burners.

Gear or Gearing—Belt, Chain, Friction, Bevel, Spur or Tooth, Spiral, Helical and Worm Gearing, etc.

Change Speed Gear—Differential Gear—Gear Efficiency—Gear Protection.

AMERICAN CYCLOPEDIA

VOLUME III.

Governing and Governors—Glues and Cements—Gradients—Graphite—Gussets.

Heat—Heavy Oil Motors—High Tension Circuit—Hoods—Horns—Hose.

Horse Power—Brake Horse Power—Indicated Horse Power—Hydrometers—Hydrostatics.

Ignition—Battery and Coil—Magneto Ignition—Synchronized Ignition—Low Tension Magnetos—Low Tension Igniter—High Tension Magnetos—The Eisemann System—The Bosch and other Systems.

Another View of Ignition—Storage Battery—Induction Coil—Make-and-Break System—Wipe Contact Breakers—The Trembler Coil Theory—Spark Plug—External Spark Gap or Intensifier—Ignition Faults and Hints—Multicylinder Ignition Timing—Preignition.

Inner Tubes—Inspection Pit—Insulation—Insurance.

Internal Combustion Engine—Its Principles, Elements and Construction—Involuntary Stops—Causes and Remedies.

Joints—Kerosene—Key — Knocking—Lamps — Acetylene, Oil, and Electric.

Laying Up a Car—Treatment of Parts—Laying Up Tires, etc.

Leaks—Leather—Levers—Liquid Fuel—Liquid Fuel Burners—Loss of Power.

Lubricating Oils—Lubrication—Lubricators.

VOLUME IV.

VOLUME V.

Study Helps and Reviews of the Cyclopedic text in the form of a Catechism on each of the most important subjects connected with the motor car; the questions and the answers thereto appearing on separate pages, so that the questions may be used separately for Self-examination on any of the subjects treated in the Cyclopedia.

The subjects on which a full set of Questions and Answers is given include the following: Axles, Batteries, Body Work, Brakes, Carburation and Carbureters, Change Speed Gear, Clutches, Coils, Cooling Systems, Driving, Electric Cars, Gasolene Vehicles, Gear or Gearing, Governing and Governors, Ignition, Internal Combustion Engines, Lubrication and Lubricators, Magnetos, Motors, Motorcycles, Piston and Rings, Repairs and Adjustments, Shafts, Steam Cars, Ignition Timing, Transmission, Wheels and Tires.

VOLUME VI.

A History of the Automobile from its inception and of the Marvelous Growth of the Motor Car Industry in the Twentieth Century. Covering the development of Self-propelled Vehicles from the earliest days and the crudest models; showing the Progress made in the Nineteenth Century and the rapid annual advances of the past decade.

Also the History and Records of Speed, Endurance and Reliability Contests, Exhibitions, etc.

HOW TO USE THE CYCLOPEDIA.

Every term, phrase, and subject connected with motor cars and motoring will be found in heavy black type—thus **Carburation, Repairs and Adjustments**—in regular alphabetical order in the pages of the Cyclopedia.

Usually, therefore, the reader has simply to turn to the proper letter, when he wants information on any given subject, and he will there find it in its alphabetical place.

If it be an important subject, much of the information given is arranged under sub-heads centered in the page, and these can be easily scanned to find the exact point aimed at.

Thus, suppose one desires information regarding Detachable Bodies. Turning to the word **Body,** in its alphabetical place, he will find that "Body Types" are fully discussed under the heading **Carriage Work.**

Under the latter heading he will quickly find the sub-head "Detachable Bodies," with the information desired.

Suppose a discussion arises as to the proper pronunciation of the common word **Chauffeur.** In a few seconds the word can be found in its alphabetical place under "C," and there the question of pronunciation is discussed, and the approved pronunciation indicated very clearly.

In many cases numerous cross-references are made to cover a single subject, or the words of a much used phrase.

Thus, information regarding the starting of automobile engines will be readily found by turning to either the word **Starting** or the word **Engines** in its alphabetical place.

If the reader turns to **Starting,** he will find references to the articles under **Driving, Easy Starting,** and **Difficulty in Starting;** and these headings when turned to alphabetically will give the information required.

Such cross-references form an important and very useful part of the work, rendering it easier to find any particular kind of information which the reader may desire at the moment.

In hundreds of places throughout the work, all the important words of subject titles and phrases have been listed in their alphabetical place with cross-references to the main article in which the information appears, so that the latter may surely be found no matter under what head it is sought.

Thus, to take a simple example, the article on "Removal of Piston Rings," may be found by turning to **Removal,** or to **Piston,** or to **Rings,** since the cross-reference under each will inevitably point to the proper article following the sub-head "Removal of the Rings" under **Engines.**

These cross-references, with the sub-heads, will be found especially useful in getting at information contained in lengthy articles, sometimes occupying many pages because of their importance, as those under the headings **Carbureter, Change Speed Gear, Ignition, Repairs, Transmission, etc.**

In such cases too, the catchwords at the top of each page will be found useful in finding the proper black letter side-heads which form the alphabetical vocabulary of the Cyclopedia.

American Cyclopedia of the Automobile.

A

A. A. A.—Abbreviation of American Automobile Association.

Abrasive—Any hard substance, as carborundum or emery, used for grinding or wearing away a softer substance.

Absolute Figures—In calculations of temperature and pressure for heat engines absolute figures, so called, are generally used. Thus absolute pressure is that measure of pressure which includes atmospheric pressure. It is given as the sum of the gauge pressure and 14.7, the latter representing in pounds the pressure of the atmosphere per square inch. Similarly, absolute temperature is temperature measured from the absolute zero, and is arrived at by taking the sum of the thermometric temperature and the constant 461, the latter being the number of degrees Fahrenheit from zero to the absolute zero of temperature as scientifically calculated. Absolute zero is defined as the lowest possible temperature which the nature of heat permits.

Absorbers, Shock—See Springs.

Acceleration—The rate of change of the velocity of a moving body, as an automobile. The acceleration is said to be uniform if the body gains the same velocity in any constant direction in equal successive portions of time. A constant force produces uniform acceleration in all cases. The force of friction, which resists the motion of a sliding body, is said to give it minus or negative acceleration.

Accelerator—A device for regulating the speed of an engine by modifying the action of the governor. The latter is an automatic device set to prevent the engine running beyond a certain number of revolutions per minute and the accelerator is an attachment worked by the driver, whereby the controlling action of the governor can be varied or suspended. In this way the engine is allowed to run at an increased speed. The accelerator is operated either by a lever placed at or near the steering wheel or by a special pedal. In some cases both are fitted. See Governor, Internal Combustion Engine.

For the purposes of hill-climbing, it is necessary and desirable that the engine should exert its maximum power, and to enable this to be done an accelerator is fitted. It is a simple mechanism which is made to operate the throttle valve, so that when the speed of the engine exceeds its normal, the amount of gas passed to the engine is cut down by the governor, and the speed so automatically controlled. By depressing the accelerator pedal, the governor is cut out of action and the throttle valve kept open, so that the full speed and power of the engine are developed, which in many cars enable all ordinary gradients to be surmounted without changing gear. When, however, the car fails to climb an exceptional hill, and resort to a lower gear is necessary, the governor should be allowed to operate during the period of changing gear, and the accelerator again depressed so as to keep the power of the engine up. Should, however, the ratio of the gearing permit the engine speed to be duly increased, the governor might be allowed to operate with advantage.

Accelerator Pedal—See Pedals.

Accessories—See Tools, Stores, Lamps, Horn, etc.

Accessories, Fitting to a Car—See under Driving.

Accessories: Their Use and Repair—The comfort and safety of automobilists depend largely on the correct adjustment of an almost infinite number of details, and amongst these the accessories have to bear a share of the responsibility.

A horn which refuses to sound when required, a lamp which burns but dimly, a pump with which the deflated tire can be only partially refilled may, any of them, lead to disaster. Caution—that necessary qualification of the reliable motorist—suggests the due care of these lesser, but not unimportant, items.

Bells—Foot bells were formerly much in evidence, and might have become more usual had they been more solidly constructed. As it is, the repairer usually shuns them, as the work of rebushing the worn action of one of these bells would prove most unprofitable, not from any inherent difficulty, but from the time occupied.

Pumps—Pumps usually require only the occasional fitting of a new leather cup. This is easy, even for a novice, if he will only exercise a little care to avoid cutting the edge of the cup, when replacing the plunger in the tube. The plunger is usually fitted with a nut and washer, by the removal of which the old leather is released when the new one is readily inserted. The cups are not worth making, as they can be bought so cheaply, but they should be well soaked in lard oil before using.

Pressure gauges as used on tire pumps have a hard time, as they are subjected to conditions which would not be tolerated for any other type of gauge. At every stroke of the pump the gauge usually flies to its highest limit, returning as suddenly to the existing tire pressure. This action would destroy the gauge of a locomotive, and is bound, sooner or later, to weaken the tube and cause the gauge, although correct when new, to "lie like a gas meter," by indicating, perhaps, 20 pounds per square inch more than it should. It is necessary, therefore, that the gauge should be calibrated occasionally, taking care that it is compared with a really reliable standard gauge. Many tires must have been condemned as having worn badly when constantly pumped up to 90 pounds pressure by the user's computation, when the real pressure has possibly been anything from 80 down to 70 pounds.

Lamps—Of all kinds of accessories the lamps provide the

largest number of patients for the accessories hospital, and their ailments can easily be divided into two classes, (a) breakages and (b) faults in burning.

The former class is larger than many motorists would imagine, for if the lamps are to be well placed for illumination, they will also be in such a position as readily to come into contact with any obstacle.

Curiously enough, this class includes many lamps which have never been used, as many persons carry lamps to complete the tout ensemble of the car, rather than for actual night work. Again, novices often—and experienced drivers sometimes—misjudge distances, to the great detriment of the lampwork, which cannot be expected to withstand the impact of the great weight of the car, even though it be moving but slowly.

In the case of acetylene lamp smashes, whether from miscalculation of distance as above or those occurring in collisions, not only is the appearance of the lamp spoiled, but its internal economy is often disturbed, so that no repair should be considered complete until every gas tube and joint has been carefully tested for leakage. The explosion which follows a leakage is rarely dangerous, but often alarming, as the report is sometimes very sharp.

The damage usually most conspicuous is the inevitable bruising of the outer shell of the lamp, and some ingenuity is required in selecting or adapting tools to use as anvils or "stakes" for the smoothing-out process. If the shock has been heavy, the metal buckles, producing folds so close that time and care must be expended to prevent cracking the metal, which would seriously weaken the structure, and also spoil its appearance. Small bruises may be dealt with in the way suggested below for dealing with horns. In cases where the lamps have been well designed, so that the parts are interchangeable, it is often quicker and cheaper to procure new parts from the maker.

As in the case of engines, the cost of the actual repair is frequently much less than the expense of taking the lamp to pieces, and reassembling the parts when the repair has been

effected. This necessary expenditure of time sometimes makes repair charges look excessive, and the buyer of new lamps will do well to ascertain if those offered him are designed with a view to the ready replacement of any damaged portions. The expensive factor of the lamp is not the metal, glass, etc., of which it is composed, but the time of the mechanics who construct it, and the whole labor of correct building and adjustment of the various component parts of the lamp may be annulled in a moment by an untoward movement of the pedal or steering wheel.

A bad smash often injures, not only the body of the lamp, but also the generator, and as some of these are much more complicated than is needful, the repairer should make sure, before dismounting them, that he is clear as to the position and purpose of each part. Every repairman could, if he would, tell of wrecks of lamps which had been overhauled by those who had not used this precaution.

Faults in burning in acetylene lamps arise from many causes. Faulty ventilation is not common, for the acetylene flame is so strong, and, if the expression may be allowed, so stiff, that it will bear air currents which would extinguish any other flame. For this reason the ventilation usually errs on the side of supplying more air than is really needed; nor does this call for any alteration. Insufficient air supply is shown by a red flame, and may be corrected by piercing extra holes, or enlarging those already existing, taking care that no air current plays directly on the flame.

Horns—An accessory with which the novice soon becomes acquainted is the horn, and it is favored with more constant attention than any other of the car's furnishings. A perfect horn should deserve the motto "Semper paratus" (always ready), for one never knows what may issue from the next turning or cross-roads. The reeds which actuate the majority of the horns in use are (more or less) musical instruments, which require careful tuning by experienced hands. It often occurs that a horn that fails is handed to a man, thoroughly trained perhaps in engineering, but without knowledge of the

method of handling this work, and in most cases he first attacks the vibrating tongue. The man of experience, on the other hand, would probably turn his attention to the reed proper, that is, the shell, against which the tongue beats, as it is usually not only better, but also easier, to effect the needed alteration in this way.

Sometimes a little dust between the reed and tongue will entirely spoil the tone, and many reeds are ruined by rough handling with the view of removing this "matter in the wrong place." A sheet of thin paper drawn down the back of the tongue will usually do the work, without fear of any injury to tongue or reed.

The quality of tone is chiefly determined by the size and proportions of the body of the horn, but yet the repairer is often requested to "fit a good deep reed" to a small horn, which is like asking for a reed of bassoon tone for a clarionet.

Another fact, apparently not widely known, is that the length of the horn extension sometimes affects the tone considerably, counter vibrations being set up in the flexible tube which considerably weaken the issuing tone. Experience shows that the horns of very deep tone are not so durable as those somewhat higher in pitch, the apparent cause being that the slow, but wide, vibrations cause "fatigue" of the metal tongues, and reduce the erstwhile diapason to a guttural croak with little carrying power.

Accidents cause bruises, not to say dents, and for their removal the repairer should be armed with mandrels of various shapes, to suit the varied curves, the procedure being fairly obvious.

Small bruises, beyond the first bend, can sometimes be dealt with from the outside. With a light, clean hammer, tap gently round the bruise, and the center will be seen to rise gradually. Do not hurry, for if the process is slow, it is quicker than taking the horn to pieces and refitting, and with care a good surface may be obtained. Some repairers resort to the expedient of soldering a piece of wire to the center of the hollow, and

thus pulling out the bruise, afterwards removing the wire and solder, but this course is not always applicable.

The indiarubber bulbs commonly used are not an ideal means of obtaining the wind supply, and we must depend on the careful selection of bulbs of suitable consistence, neither so thick as to tire the hand, nor so thin as to fail to regain their fullness when released.

Accidents—In case of accidents, such as collision, the first consideration, of course, should always be the care and comfort of the injured, if any. The following detailed recommendations are made by a driver of wisdom and experience:

1. Take the names and addresses of bystanders who witnessed the accident, also of the passengers in the colliding vehicles.

2. Note the side of the road on which the car was going or standing, also the side on which the other vehicle was going, and make a written entry at once.

3. Note the speed of both vehicles as near as you can say and make a written entry at once.

4. Note the exact width of the road and condition of the surface, height of fences, curb, lamp posts, etc., if these matters are liable even remotely to be brought in.

5. Note what signs the other vehicle gave of its approach —horn, bell, voice, etc.; also ditto for your own car.

6. If after dark note what lamps were alight, and on what side of both vehicles the lamp or lamps were fixed.

7. Measure the width of both vehicles over all, the width of track of both and the distance of each wheel track from the curb, etc., with sketch.

8. Record the exact time of day and make notes as to the amount of other traffic on the road. Collect information as to the amount of traffic to be expected on that road at that spot at about the time and date in question.

9. Record the number of the other vehicle, and if you can manage it get the driver's name and address.

10. If the accident is due to an obstruction in the road, badly filled trench left by a gas, electric or water company,

unlighted pile of stones, water or gas pipes left on the road, etc., note the conditions carefully and if possible photograph the obstruction.

11. If a person has been injured take a careful note of the injury. Drive the injured person if possible to a doctor and have him examined as to extent of injury.

12. Under no circumstances give any money to any person who may be aggrieved; it will invariably be used against you as an admission of liability. Do not verbally admit any liability, and write no letters of regret or otherwise save with legal advice, which may, if you are a member of one of the automobile clubs, be obtained at small cost through the secretary of the organization in question.

The worst accidents are due to neglect of steering gear and brakes.

Accumobile—A term applied in Europe to an electromobile operated by means of accumulators. See Electromobile.

Accumulator—An arrangement of chemically prepared lead plates in a box or cell of some acid-resisting material, combined with an acid solution. These plates can be charged with an electric current from a primary source and are then converted into a chemical state which enables them in their turn to give a current of electricity by a secondary action. As the current can be taken from the accumulator as required, it serves as a storage battery. See Battery, Cell, Acid.

Acetone—An inflammable liquid which possesses the property of absorbing acetylene gas freely, burns with a bright blue flame and is used as a solvent, carbureting agent and illuminator for searchlights, etc.

Acetylene—A somewhat poisonous gas, a compound of carbon and hydrogen. It can be formed directly from these elements, when an electric arc between carbons is burnt in hydrogen; for general lighting purposes, however, it is always prepared by the action of water on calcium carbides. It has a distinctive odor and is also to a limited extent soluble in water. When burning one cubic foot of acetylene, two and

one-half cubic feet of oxygen are consumed, forming two cubic feet of carbonic acid gas. See Calcium Carbide.

Acetylene Lamp—See Lamps.

Acetylite—Calcium carbide treated with glucose and used to secure a slow and more uniform production of acetylene gas.

Acid—A term which, when used in connection with automobiling, usually refers to the liquid used in the accumulator. It is composed of five parts of water to one part of sulphuric acid, and is of specific gravity 1.250. Sufficient must be put into the accumulator cells to cover the top edges of the plates by about one-eighth inch, but the acid should not reach up to or cover the lead connecting bars inside the cells. Great care should be used in handling this acid, as it is oil of vitriol and corrosive. It will destroy clothes or fabrics, on which it makes first a red spot, then a hole. If any acid is spilled on clothing, woodwork, brass, etc., it should be immediately washed off with water containing a little ammonia.

Acid, Chromic—An acid used as a depolarizer in primary battery cells.

Acid Cure—A preparation used for patching rubber tires.

Acid, Hydrochloric—The muriatic acid of commerce, used with scrap zinc in soldering.

Acid, Picric—A compound used with gasolene to increase motor efficiency.

Acid, Sulphuric—A colorless, odorless liquid, very useful in the arts. It is used in accumulators and charging batteries. Also called oil of vitriol. See Accumulator.

Acidimeter—An instrument for determining the purity or strength of acids.

Ackerman Axles—See Steering Gear.

Addendum—In machinery that part of the tooth of a gear which lies between the pitch-circle and the point. An addendum-circle is a circle which touches the points of the teeth.

Adhesion—A term often used as synonymous with fric-

tion. The adhesion of wheels is the friction between the surfaces in contact, acting to prevent slipping, etc.

Adhesion, Effects of in Braking—See under Brakes.

Adjusting Screw—See Screws.

Adjustment—The tightening up or slackening of a part or parts, so as to compensate for wear on such parts, or to reduce friction arising from overtight bearings. See Overhauling, Repairs and Adjustments.

"Little and often" is an excellent motto in the care of motor cars, the "little" being a consequence of the "often." The great thing is to give the attention regularly. All working parts should be adjusted to move freely but without shake. This ensures the highest efficiency and absence of noise. Spring washers are often useful in attaining these results where proper means are not provided for adjustment. All nuts used for positive gripping purposes should be secured by castle locknuts, with split pins passing through a hole in the bolt and through the slots in the nut.

Adjusting Bearings.

As a rule, the owner will do well not to attempt the adjustment of plain and roller bearings. Ball bearings are comparatively easy to adjust, if provision is made for adjustment. At one end will be found a locknut, and on the same screw a cone. When the locknut is released the cone may be screwed along the spindle either into or out of the bearing. It should be screwed in until it will go no further without using force, then it should be unscrewed about half a turn. Now, if the locknut be retightened, it will probably be found that the bearing will work freely and without a shake. It is better to have just a perceptible shake than to have a bearing too tight, and the final tightening of the locknut will usually tighten the bearing itself a little, owing to slackness in the screw threads.

A scrunching noise in a bearing should receive immediate attention, the bearing being taken apart in order to discover the cause. It may be found to be due merely to the presence of some grit, though that is bad enough. In this case a thor-

ough cleansing of the bearing and lubrication will cure the trouble. If one of the balls is found to be broken, all the pieces must be removed and a new ball inserted. But unless a new one of exactly the right size can be procured, it is best to run the bearing with a ball short for the time being, as, should the new ball be a shade too large, it will almost certainly cause trouble. When the bearing is apart the cones and cups should be carefully examined for scores and cracks, as, if these are found, the parts affected should be renewed at the earliest opportunity. In some cases, where the damage to the bearing parts is serious, it is best to remove the balls and let the bearing run on the plain surfaces as far as the nearest point available for repairs. If a wheel spindle has been cut into so as to weaken it materially the load should be lightened as much as possible or the run discontinued entirely pending repairs.

Brake Adjustment.

The adjustment of the brakes is even more important than that of the bearings. They require treating according to their individual construction. Two points, however, should be borne in mind: first, that the pedal or hand lever should not be at the limit of its stroke, even when the brake is hard on; and second, that the braking surfaces should not rub anywhere when the brake is off.

A car should not be run with either the wheel bearings or the steering crossbar joints very slack, as the wheels will wobble under these conditions and the bearings and tires will get badly worn.

Adjustments, Ignition—See under Ignition.

Adjustment of Low Tension Plugs—See under Ignition.

Admission—In a gas engine the letting in of the mixture by suction to the cylinder, to be compressed by the return stroke of the piston.

Admission of Steam—See under Cut-off.

Admission Pipe—The inlet pipe leading from the carbureter to the admission valve chamber. Its internal diameter should not exceed one-fourth the diameter of the motor cylinder.

Admission Valve—The inlet or induction valve. See Valves.

Advance Sparking—A method whereby the time of the igniting spark occurring in the cylinder or cylinders may be regulated. This is done by completing the electric circuit at an earlier or later period, as desired. By advancing the ignition lever the spark is made to occur immediately before the piston enters on the down or explosion stroke, and thus, when the piston is working at high speed, the full force of the explosion, or rather expansion (which takes an appreciable time to develop), is attained when the piston has got over the dead point and has just commenced the down stroke. In this way the full power of expansion is availed of, but this is only possible when the piston is moving rapidly, as otherwise the force of the expansion would act on the piston ere it had entered on the down or explosion stroke.

Thus if the spark were advanced when starting the engine, the expansion would take place when the piston was on the up or compression stroke. The impact would drive the piston downward in the reverse direction with a jerk, and so would cause that unpleasant mishap known as a **back fire.** See Back Fire.

Generally speaking, the spark is advanced for high speeds on the level and is retarded for starting, for running slow on the level or for uphill work, where the piston speed is necessarily reduced. It is kept in a medium position under ordinary conditions. It is bad practice, however, to retard the spark unduly except when starting, for this leads to imperfect combustion, overheating of the engine and fouling of the valves. See Timing, Governor, Internal Combustion Engine.

Advancing the Spark—See under Driving.

Aerodrome—An inclosure or tract of land set apart for the testing or flight of aeronautical apparatus, as aeroplanes, etc.

Aeronaut—One who sails or floats in the air.

Aeronautics—The doctrine, science or art of aerial navigation.

Aeroplane—A flying-machine, usually having lateral wings and steering devices and often equipped with a gasolene or other motor to operate propellers, etc.

Aerostat—A machine sustaining weights in the air; a flying-machine.

Aerostatics—The science which treats of the weight, pressure and equilibrium of air and other elastic fluids and of the equilibrium of bodies sustained in them.

After-burning—In a gas motor, a continued burning of the charge after the explosion.

After-firing—An explosion in the muffler or exhaust pipe. To be distinguished from back-firing or ignition at the wrong point in the cycle with reversed piston movement. See Back Fire.

After the Drive—See under Driving.

A.-h.—Abbreviation of the term Ampere-hour.

Air Bottle—A metal receptacle for compressed air, used for tire inflation, and conveniently carried on the car. Air bottles have robbed the possibilities of puncture of half their terror. Each bottle will inflate a certain number of tires, according to size, say from 4 to 35 tires, and will partially inflate many more. As soon as the bottles are emptied of compressed air they can be exchanged for filled ones at the makers' agencies.

Air-bound—Applied to the phenomenon caused by an accumulation of air in any pipe. It usually occurs in filling up the water-tank, and may be removed by opening a drain cock in the circulation system and allowing the air to escape before the pressure of water on filling the tank. In cars where a filling cap is provided at the highest point of circulation, as, for example, above the cylinder head, air bubbles may be removed or prevented by filling the tank from this opening, as the flow of water to the tank prevents an air-lock. The presence of the air in the pipes prevents free circulation, resulting in overheating the motor and consequent loss of power. See Air Lock, Repairs and Adjustments.

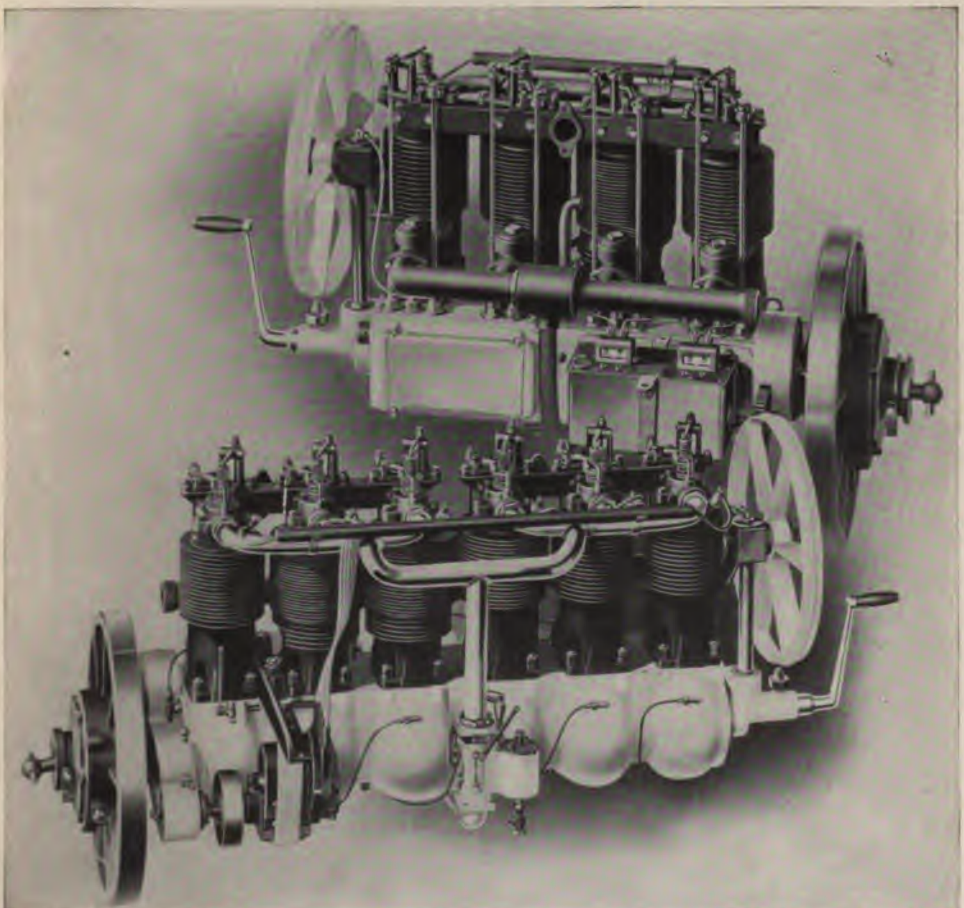
Air Cooling—A method of dispersing the heat generated in the cylinder by the working of the motor. Air is a bad conductor of heat and is found useful for cooling hot parts by its action of convection. A number of ribs or radiators are cast or otherwise formed around the cylinder to give the greatest superficial area possible and the motor so placed on the vehicle as to be subjected to the current of air met or formed by the running of the car. When the motor is stationary cooling still goes on, though in a much less degree, by reason of the air in immediate contact with the cylinder ribs becoming heated and so rising upward, a fresh body of cooler air replacing it and a constant current being thus obtained. In some cases a fan, driven off the crank shaft, is used to increase the current. Formerly it was held that air-cooling was impracticable for vehicle motors, though generally employed for small motors, such as are fitted to motorcycles, but many American vehicles, both light and heavy, of recent manufacture have successfully used air-cooling devices.

A notable example of air cooling employed for a car is found in the Frayer-Miller system.

The cylinders have flanges cast on them in the usual way, which are surrounded by a light steel casing, so that the air is bound to pass through the channels thus formed. At the back of the casing a high speed centrifugal fan revolves, and causes a strong current of air to flow round the cylinder. This method has been found to be remarkably efficient.

The Franklin Air-Cooling System.

The air-cooled cars long associated with the name of Mr. H. H. Franklin are the leading modern representatives of this system of engine cooling. The Franklins have been built on the same principle since 1901 and their success is unquestioned. The fundamental principle of the Franklin idea is light weight, with great strength and simplicity and the beginning is air-cooling, which, the manufacturers claim, gets rid of useless weight and useless complication and allows the whole automobile to be "refined, simple and strong."



The Franklin Air-Cooled Engine.
Upper Picture—1909 D Engine (4-cylinder) Exhaust Side.
Lower Picture—1909 H Engine (6-cylinder) Intake Side.

The Franklin cylinders are made of cast iron, and about them are placed a series of thin, heat-radiating flanges of phosphor bronze. These flanges perform an important part in the air-cooling which is a distinguishing characteristic of the Franklin engine. By them the heat is transmitted directly to the air, a blast of which is driven about them by a fan. There is no water intermediary in the cooling process.

Three other devices specially mark the Franklin cylin-

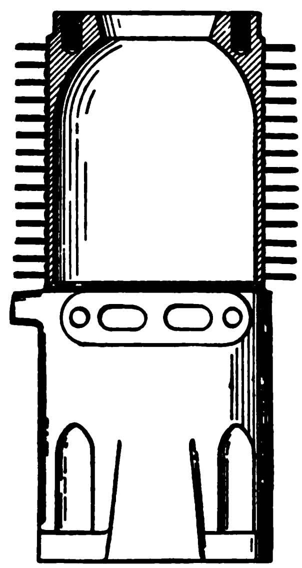


Diagram of The Franklin Air-Cooled Cylinder.

ders. They are the auxiliary exhaust, the concentric valves and the dome head of the cylinder. The auxiliary exhaust is at the base of the cylinder, opening just after the piston completes the power stroke. Through it pass off seventy-one per cent of the burned gases, a fact which goes far to prevent heating. See full page photographic illustrations.

The intake and main exhaust valves are concentric in the top of the cylinder. The fact that they are concentric permits a maximum size of valve in a small combined space.

This insures a good sized charge of gas and results in a maximum of power.

This arrangement of valves makes possible the dome shape of the interior of the cylinder head. By this the interior surface is at a minimum without a reduction of the exterior, or heat radiating surface. The interior is without irregularities in which dead gas can gather. This insures full clearing of the cylinder and the subsequent taking in of a full charge of fresh gas.

The Knox Air-Cooling System.

Another well-known air-cooling system is that employed for several years on the Knox cars. The latest Knox cars, however, include two water-cooled models, and one air-cooled model, the latter being made for those preferring this type of motor construction.

The Knox air-cooled motor is a four-cycle engine, the radiating surface being obtained by screwing spines of wrought steel into the gray iron cylinder bodies. In a large Knox cylinder, 5x8 inches, no less than 1800 of these cooling spines are applied to each individual cylinder. The photographic illustrations show these spines very clearly.

The smaller Knox cars, of course, do not require so much radiating surface, and the 4⅜x4¾ inch cylinders in a Knox motor, with four vertical cylinders tandem, have only about 1,000 of these cooling spines applied to each cylinder.

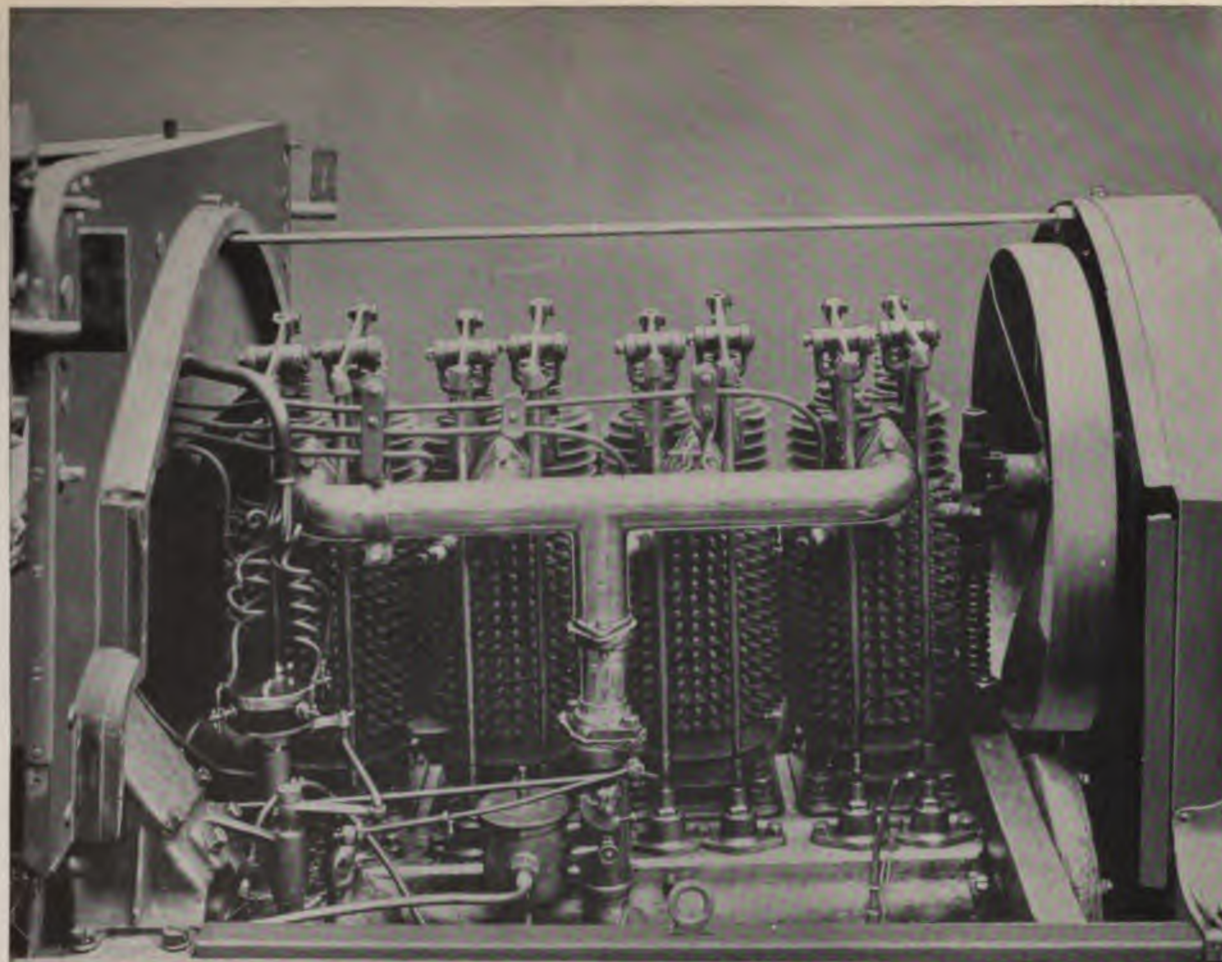
The motor has a fan in front driven by a belt to which an automatic spring tightener pulley is attached. The fan makes two turns to one turn of the crankshaft; it is large and very strongly driven on ball-bearings.

Air Inlet—An opening in the float chamber of a carbureter to admit air.

Air Leak at Plug—See Loss of Power.

Air Leak in Manifold—See under Missing Explosions.

Air-lock—When a bubble of air lodges in the top of some bend in a pipe it will occasionally stop the water circulation



KNOX MODEL H. POWER PLANT.
Showing System of Pins for Air-Cooling.

or seriously impede it, causing what is called an air-lock or an air-bound condition. See Air-bound.

In such cases filling the radiator or tank with water will fail to remove the trouble. Even the working of the pump merely tends to compress the extremely elastic air bubble instead of moving it along with the circulation of the water. One is liable to think that the pump is not rotating satisfactorily, since the circulation is stopped altogether, but do not start dismantling the pump, which is invariably a laborious and often a dirty task, until you have taken steps to remove the chance of air-lock.

Many cars are so designed that this occurrence in the water system is an impossibility. In such cases a mechanical cause must be sought for overheating. All cars are not so advantageously arranged. Occasionally, to secure the convenience of greater accessibility of the pump, or because of the type of radiator chosen, the designer has involved the pipe work in such bends that air-lock occurs every time the radiator is emptied and refilled. Air-lock can generally be removed by running the engine so that the pump is in full operation; opening the water plug at the lowest part of the water system; opening the air relief cock, which is usually provided at the top, and continuing to allow a stream of fresh water to flow in through the filling-up nozzle as fast as it flows out at the plug. Air-lock can be discovered by feeling the radiator and pipe work at various places with the hand, after the engine has been running a few minutes. If a part of the system persistently remains cold there is no circulation. If a fairly uniform warming up of all parts be obtained, everything is probably in order in this respect. See Repairs and Adjustments (Water Circulation).

Air-pump—See Pressure Pump, under Pumps.

Air Resistance—The resistance offered by the atmospheric air to a plane surface in motion. It does not interest the automobilist until the car attains a speed of 10 to 12 miles an hour, when it assumes increasing importance. Scientists have esti-

mated that the resistance of air to a flat surface varies as the square of the velocity nearly. The figure of a plane makes no appreciable difference in the resistance, but the convex surface of a hemisphere, with a surface double the base, has only half the resistance. At high velocities the resistance becomes nearly a constant quantity. The resistance of the air to a train of cars in a dead calm has been found to be one eighty-ninth of their weight.

A. L. A. M.—Abbreviation of Association of Licensed Automobile Manufacturers.

A. L. A. M. Rating—The horse-power rating of an automobile approved by the Association of Licensed Automobile Manufacturers.

A. L. A. M. STANDARD HORSE POWER FORMULA

(Bore of cylinder squared x No. of cylinders ÷ 2.5)

BORE		HORSE POWER			
INCHES	MILLIMETERS	1 CYLINDER	2 CYLINDERS	4 CYLINDERS	6 CYLINDERS
2 1/2	64	2 1/2	5	10	15
2 5/8	68	2 3/4	5 1/2	11	16 1/2
2 3/4	70	3	6	12 1/16	18 1/8
2 7/8	73	3 5/16	6 5/8	13 1/4	19 5/6
3	76	3 3/5	7 1/5	14 2/5	21 3/5
3 1/8	79	3 29/32	7 13/16	15 5/8	23 7/16
3 1/4	83	4 1/4	8 1/2	16 15/16	25 3/8
3 3/8	86	4 9/16	9 1/8	18 1/4	27 1/3
3 1/2	89	4 15/16	9 4/5	19 3/5	29 2/5
3 5/8	92	5 1/4	10 1/2	20 1/2	31 1/2
3 3/4	95	5 5/8	11 1/4	22 1/2	33 3/4
3 7/8	99	6	12	24	36 1/16
4	102	6 2/5	12 4/5	25 3/5	38 2/5
4 1/8	105	6 13/16	13 5/8	27 1/4	40 13/16
4 1/4	108	7 1/4	14 1/2	28 15/16	43 1/3
4 3/8	111	7 5/8	15 5/16	30 5/8	45 15/16
4 1/2	114	8 1/16	16 1/5	32 2/5	48 3/5
4 5/8	118	8 9/16	17 1/8	34 1/4	51 3/8
4 3/4	121	9	18	36 1/16	54 3/16
4 7/8	124	9 1/2	19	38	57
5	127	10	20	40	60
5 1/8	130	10 1/2	21	42	63
5 1/4	133	11	22	44 1/16	66 1/8
5 3/8	137	11 9/16	23	46	69 5/16
5 1/2	140	12 1/16	24 1/5	48 2/5	72 3/5
5 5/8	143	12 5/8	25 5/16	50 5/8	75 15/16
5 3/4	146	13 1/4	26 1/2	53	79 1/3
5 7/8	149	13 13/16	27 5/8	55 1/4	82 13/16
6	152	14 2/5	28 4/5	57 3/5	86 2/5

Alcohol—A volatile, inflammable and colorless liquid of a penetrating odor. It can be obtained from sugar by fermentation, this substance being split up into alcohol and carbonic acid. Starch, which is the main constituent of all grain and potatoes, etc., also yields alcohol. The starch is first converted into several forms of sugar, such as maltose and dextrin, and from these alcohol is obtained by distillation.

As sugar and starch in their various forms are obtainable from almost every vegetable product, it is evident that alcohol can be obtained in inexhaustible quantities, and thus would furnish a certain supply of fuel under all circumstances. Alcohol can also be obtained from calcium carbide by a chemical process; from peat, wood, etc.

Efforts have been made in recent years toward the production of this spirit for use in internal combustion engines, and the removal of the United States tax on alcohol denatured according to government regulations is expected to have an effect sooner or later on the automobile industry. It may be manufactured very cheaply and is cleaner and less dangerous in use than gasolene, though its heat equivalent is smaller. It evaporates less easily than gasolene, explodes less violently and maintains its mean explosion pressure rather better.

Alcohol is denatured in various ways, as by mixing with methyl or wood spirit and some other hydrocarbon, to prevent its use as a beverage.

A car designed to run with alcohol can run with gasolene, but the reverse is not always true, owing to difficulties of carburation. Many spray gasolene carbureters can on emergency be arranged to use alcohol, but with the surface type of carbureter extra heating from the exhaust is likely to be required.

In order to compete in price per volume alcohol should be less than two-thirds of the price of gasolene. Both alcohol and gasolene, with the same volume of air, might produce about the same amount of heat (or power), and we might therefore expect that with the same cylinder capacity the power would be the same, but on the level a gasolene car

driven by alcohol is slightly less speedy than when running with gasolene. As a suggestion toward an explanation, there is the fact that the volume of alcohol required to burn a given volume of air (say a cylinder full) is greater than the volume of gasolene required for the same purpose in the ratio of 3 to 2. Uphill the motor is found to be slightly more powerful than when running with gasolene at the same speed. An explanation of this is that the explosion pressure is better maintained with the more slow-burning alcohol when the car is running slowly.

Cars running with alcohol are supposed to make less noise with their gear than gasolene cars, due to less sudden combustion.

The power of motors (with gasolene, alcohol or other fuel) is proportional to the heat (calories) produced by a given volume of mixture (air and fuel), and not to the calorific value of the fuel. The consumption of fuel for a given power is proportional to the calorific value of the fuel, and in this respect alcohol, to the extent of 3 parts, will be required to do the work effected by gasolene, 2 parts.

In using alcohol in a car designed to run with gasolene, three facts must be remembered:

1. That the spray nozzles of the carbureter will have to pass nearly 50 per cent more liquid, and must therefore be made larger.

2. That the carbureter must be heated considerably more, owing to the smaller volatility of the alcohol.

3. That a given amount of alcohol may only carry you two-thirds of the distance covered by the same weight of gasolene.

Alcohol, though the larger weight used per horse-power now makes it somewhat less convenient, besides more expensive than gasolene, may soon be very cheaply made, and is therefore a safeguard against any great rise in price of gasolene.

An advantage of alcohol is that it possesses a fixed and homogeneous chemical composition. It can now be obtained

commercially in an almost chemically pure state, and it possesses the advantage over gasolene that it can be made and used in any climate.

Alcohol, Acetylated—Ethyl alcohol denatured by the admixture of acetylene.

Alcohol, Denatured—Spirits of wine rendered unfit for drinking by the admixture of methyl spirit (wood alcohol), sulphuric ether, oil of turpentine etc. A common formula for engine fuel consists of ten parts by volume of methyl spirit and half a part of some other hydrocarbon to each 100 parts of 90 per cent ethyl alcohol.

Alcohol, Wood—Methyl spirit.

Alcoholometer—An instrument for determining, by means of a graduated scale, the percentage, either by weight or by volume, of pure alcohol in a liquid.

Alignment—Adjustment to a line. Also written Alinement.

Alloy—An artificial compound of two or more metals combined while in a state of fusion, as of copper and tin, which forms bronze. The alloys are numerous, as the brasses, bronzes, solders, etc. See Soldering.

Alternating Current—That form of electric current in which the impulses are in alternate directions, changing from positive to negative direction and back rapidly. Such a current must not be used for charging accumulators, except through the medium of a special instrument known as a rectifier or converter. See Battery, Electricity.

Aluminoid—An alloy of aluminum, tin and zinc used for crank-chambers and gear-cases. It is light, strong and easily worked.

Aluminum—An extremely light, malleable and ductile metal of a dull silver color. It does not oxidize or tarnish when exposed to dry or moist air. Pure aluminum, directly it meets with oxygen, combines to form a thin, transparent coating, which, while preventing further oxidation, makes it most difficult to solder. It is used very extensively for the panels and

castings of automobiles on account of its lightness; also in the form of alloys with other metals.

Aluminum Solder—See under Useful Information.

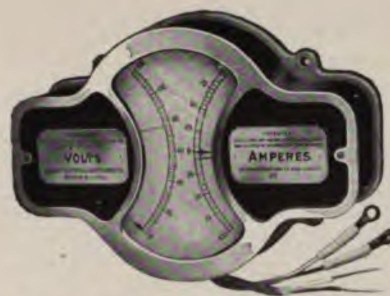
Amalgam—An artificial metallic mixture containing quicksilver. Amalgams are used for coating the zinc plates of a battery, for the protection of metals from oxidation, etc.

Amalgamate—To mix or alloy with quicksilver. The zinc plates used in the voltaic battery are always amalgamated by immersing them in mercury, for by this means a surface of pure zinc is in effect obtained, and when the circuit is opened the waste caused by the local currents or local action due to impurities in the zinc is prevented.

American Automobile Association, The—An organization established in 1902, with the following main objects: "Uniting in one body of all the automobile clubs and individual motorists of the United States, and thus the promotion and furtherance of legislation, reasonable enforcement of motor laws and ordinances, sportsmanlike contests and reliable records, as well as all movements, both federal and local, toward the construction and maintenance of good roads. The Association is commonly known as the A. A. A. and maintains headquarters at 437 Fifth avenue, New York City.

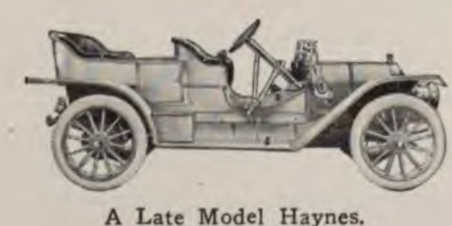
Ammeter—An instrument for indicating the strength in amperes of an electric current or testing batteries, used by inserting it in the circuit so that the current passing round the circuit flows through the ammeter. Also called Amperemeter.

Ammeters are of extremely low resistance, as their magnetic coils which actuate the needle are simply a turn of thick wire, so that they do not consume any power, but only indicate the strength of the current passing, by the magnetic effect caused on the needle by that current. In consequence of the very low resistance of an ammeter, it should never be connected across the terminal of an accumulator, as it would short-circuit the accumulator, causing an enormous rush of current through the ammeter, which would probably burn it up



Weston Combined Volt and Ammeter—Model 39.

Pierce-Arrow Six-Cylinder 48 H. P. Touring Car—purchased by the United States Government for the use of President Taft. The car also has an inclosed body interchangeable with this Touring body.



A Late Model Haynes.

or spoil it. In the early days of automobiling this mistake was often made, owing to the fact that ammeters of the pocket type are very similar in appearance to voltmeters, these latter being used correctly in the above manner.

An ammeter should be used in all circuits where it is necessary to know what strength of current is passing, but they are not required in general use on gasolene cars, as the accumulator will always give the necessary current for the coil if the voltage of the accumulator registers its full value when tested with the current on. In fact, if you "take care of the volts the amperes will take care of themselves," as the two are directly proportional to each other when the resistance of the circuit is a fixed quantity. See Repairs and Adjustments.

The ammeter is now usually combined for automobile use with a voltmeter, the two instruments being inclosed in one case, with the scale of each visible to the operator.

Amperage—The quantity or strength of an electric current measured in amperes.

Ampere—The unit of quantity of an electric current.

Strictly and scientifically speaking the definition is not quite correct, but gets as near to the actual definition as can be managed in a short and simple description, and without an elaborate definition of electricity on highly scientific lines. For that reason it is used throughout this work as conforming best with the well-known water analogy, the simplest for explaining the principles of elementary electricity. Thus, if we regard the current in a battery as equivalent to water stored in a tank, we use the term ampere just as we would use gallons in referring to the water. Volts would be used to designate the pressure of the current in a wire conducting it from the battery, just as in the case of a pipe from a water tank we would measure the pressure of the water in pounds.

Ampere-hour—In ampere-hours we express the quantity of current which can be obtained in a battery for a certain time. This signifies that a current of a certain number of amperes

can be taken from the battery during a certain number of hours. Every accumulator has a limit to the rate at which the current can be taken from it without damage, and within that limit the term ampere-hours can be interpreted in any multiples of the total ampere-hours. For instance, a battery of 30 ampere-hours, which has a maximum discharge rate of 3 amperes, can give 3 amperes for 10 hours, or 2 amperes for 15 hours, and so on.

Amperemeter—See Ammeter.

Aneroid—Dispensing with fluid. An aneroid barometer is a portable barometer for indicating the pressure of the atmosphere without the use of mercury or other fluid.

Angle-iron—A rolled or wrought bar of iron in the form of an angle, used in iron constructions. When made in the shape of double angles it is called a channel-iron.

Animal-power—A man of ordinary strength can exert a force of 30 pounds for 10 hours in a day, with a velocity of 2½ feet per second, which is equal to 4,500 pounds raised 1 foot in a minute or .2 of the work of a horse.

A man can travel, without a load, on level ground, during 8½ hours a day, at the rate of 3.7 miles an hour, or 31¼ miles a day. He can carry 111 pounds 11 miles in a day.

A carrier going short distances, and returning unloaded, can carry 135 pounds 7 miles a day. He can transport, in a wheelbarrow, 150 pounds 10 miles in a day.

A horse can travel 400 yards, at a walk, in 4½ minutes; at a trot, in 2 minutes, and at a gallop, in 1 minute.

A draft horse can draw 1,600 pounds 23 miles a day, weight of carriage included.

The ordinary work of a horse may be stated at 22,500 pounds, raised 1 foot in a minute, for 8 hours a day.

A horse can exert a horse-power hour for but 6 hours a day. One machinery horse-power is therefore equivalent to that of 4½ horses.

Anion—The element of an electrolyte which in electro-

chemical decompositions appears at the positive pole or anode, as oxygen or chlorine.

Annealing—The process of treating metals, etc., by means of heat, so as to remove their brittleness and at the same time render them tough and more or less elastic. In general these results are obtained by heating to a high temperature and then cooling very gradually. The working of iron and steel by hammering, bending, rolling, drawing, etc., tends to harden them and make them brittle, and the original properties are restored by annealing.

To anneal brass, heat it till it is a dull red, and cool by plunging into water. This process, which hardens steel, softens brass.

To anneal steel, that is, carbon steel, heat it to a bright red, and very slowly cool by plunging in common sand or other bad conductor, or by leaving it in the fire and allowing the latter to die out. On a large scale the annealing is done in a furnace. See Steel.

To make iron castings malleable they must be thoroughly cleaned and then placed in an annealing furnace and packed round with finely divided oxid of iron or other substance capable of extracting carbon from the cast iron under the influence of heat. The process is a long one, lasting sometimes for 14 days, and cannot be successfully carried through without considerable experience.

Annular Valve—See Valves.

Annunciator—An electrical apparatus, usually with dial, etc., for signaling instructions to a chauffeur.

Anode—The positive pole of a voltaic current; the pole at which the current enters an electrolytic cell; opposed to Cathode, the point at which it departs.

Anti-bouncers—Contrivances to counteract the recoil of the springs. See Springs.

Anti-freezing Solutions—Liquids which freeze at a lower temperature than water and are desirable for use in the cooling system of a water-cooled engine.

There are many formulas for anti-freezing mixtures and there seems to be no particular choice about the matter, being largely a matter of preference. Wood alcohol gives splendid results, is clean, will harm no parts and is not expensive. Calcium chloride is cheap, but causes rust. Half wood alcohol and half glycerine makes a good combination, for while alcohol will permit water to boil at low temperatures, the glycerine will raise this point.

Anti-Freezing Mixtures.

Glycerine and Wood Alcohol—Equal Parts.

Percentage in water.	Freezing point, Fahrenheit.
5	28
10	25
15	20
20	15
25	8
30	— 5
33	—15

Glycerine.

5	30
10	28
15	25
20	23
25	19
30	15
35	12
40	5
50	— 2
55	—10

Wood Alcohol.

5	25
10	18
15	11
20	5
25	— 2
30	— 9
35	—15
40	—23

Calcium Chloride.

Commercial Calcium Chloride to each gal. water.	Freezing Point, Fahrenheit.
1 lb.	27
2 lbs	27
3 "	— 1.5
3½ "	— 8
4 "	—17
5 "	—39

Antimony—A metal of a white color and bright luster, which does not readily tarnish. It enters into a number of valuable alloys.

Anti-rust—See Rust.

Anti-skid—See Tires.

Anti-vibrator—The usual rubber mat fitted to the floor of automobiles does not possess a large amount of elasticity or ability to eliminate the vibration resulting from the working of machinery and from contact with the road. As is well known, most floor mats are made of some composition which possesses very small resiliency and is extremely heavy. It has been found that if an ordinary door mat is fitted to the bottom of the vehicle this almost entirely removes vibration; it is also warmer to the feet and is very easily cleansed from road dirt by the simple process of shaking, as is usual with door mats.

Anvil—In electricity, a fixed steel electrode against which a hammer, or movable electrode, strikes to close the circuit in a make-and-break system.

Applying the Brakes—See Art of Braking under Brakes.

Apron—A covering used to protect the under side of a motor car mechanism from dust and dirt.

Apron, Storm—A waterproof device for the protection of the occupants of a carriage against rain, etc.

Aquafortis—A name given to weak and impure nitric acid.

Arbor Shaft—See Shafts.

Arc Light Armature—See under Ignition; Magneto.

Areometer—An instrument for measuring the specific gravity of liquids; a hydrometer.

Arm—In mechanics, anything resembling the human arm in position or function, as a spoke of a gear-wheel, a steering-arm, etc.

Armature—A component part of the magneto electric machine, dynamo or electric motor. It is made in a large number

of patterns, the simplest being in the form of a drum with coils wound upon it, or an iron shuttle with coils of wire wound round it.

The most usual form of armature is a series of bobbins wound with insulated wire and arranged round a spindle to form a perfect cylinder. The ends of each coil are carried to a collector or commutator, from which the currents generated in the armature are taken. The armature forms the revolving part of a dynamo, and revolves on its spindle in the magnetic space or field between the poles of the dynamo electro magnets. When it is revolved in this space the coils of wire cut through the lines of force, which induces currents of electricity in the coils, these being collected at the commutator, from which they are taken by copper gauze brushes to the terminals. See Ignition; Coil.

Armature Drum—See Ignition.

Art of Driving, The—See under Driving.

Artillery Wheel—See Wheels.

Asbestos—A non-combustible silicate of magnesia, its physical appearance being well described by its synonym, mineral flax. It occurs in nature as a fibrous hornblende. Used for making washers, packings, etc., or protecting inflammable substances from the effect of heat or fire. Combined washers made of thin copper containing a lining of asbestos cord are used under the spark-plug; the combination rarely gives trouble. See Packing.

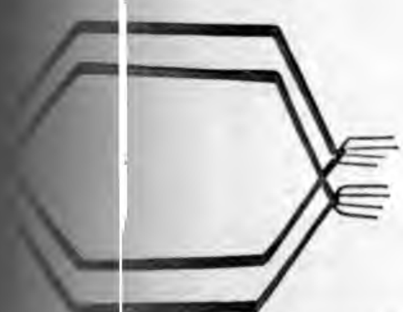
Asphalt—A bituminous material used for pavements, flooring, etc. The most interesting deposit of true asphalt or asphaltum is the so-called "pitch lake" in the island of Trinidad, about a mile and a half in circumference.

Aspirating Nozzle—An atomizing or spraying nozzle designed to reduce the liquid passing through it to the finest atoms.

Assemble—To fit together, as the various parts of an automobile or engine.

Associations, Clubs, etc.—Nearly every automobiling center

Core, Assembled, Ready to Be Wound.



Formed, Taped and Insulated, Ready to Be Wound on the Armature Core.

Wound and Ready to Put Into Machine.

in the United States now has its association or club of motor car owners—and nearly every city and town of respectable size is an automobiling center. There are also district, county and state organizations of owners, as well as the national associations of manufacturers and of owners. All of these have accomplished much good in the direction of educating the public up to the automobile, protecting owners and drivers in their rights, repressing abuses, restraining and training chauffeurs, redressing grievances, and generally doing missionary work in the best interests of those who use and do not abuse the motor car.

Much remains for the clubs and associations to do—in fact, their work is hardly started. When they agitate and labor, as many of them do, for good roads, they are performing a public service of inestimable value. It is altogether likely that an irresistible national movement toward better roads in all parts of the country will set in as one result of the advent of the automobile and of automobile clubs—and that is "a consummation devoutly to be wished."

Association of Licensed Automobile Manufacturers—An association organized in 1903 "primarily to protect the rights of its members and those of the dealers and users of cars manufactured under the fundamental patent on gasolene automobiles, known as the Selden patent." The association, which is commonly know as the A. L. A. M. has held several successful shows since January 1907. Headquarters are maintained at 7 East 42nd street, New York.

Atmosphere—The aeriform fluid which surrounds the earth; the air; a unit of atmospheric pressure.

Atmospheric Valve—A suction or automatic valve. See Valves.

Atom—An extremely minute particle of matter.

Atomizer—A device which takes its name from the function it performs—that is, the breaking up of a liquid into exceedingly fine atoms in order to combine it with air for the purpose of making a combustible gas. A distinction ought

to be drawn between atomizing and vaporizing, as in the one case the liquid is made into a gas before mixing with the air, while in the case of the Atomizer it is really not a gas at all at the moment of mixing, but only a series of very fine atomic particles. See Carbureter.

Auto—Common abbreviation of Automobile. A prefix of Greek origin, meaning self, of itself, of one's self, etc.

Autoboat—A motor boat.

Autocar—An automobile or motor car; also a specific trade name.

Autocycle—A motorcycle.

Autodrome—A course or track specially designed for automobiling.

Auto-Induction—See Self-Induction.

Autoist—One who drives or uses automobiles; an automobilist; a motorist.

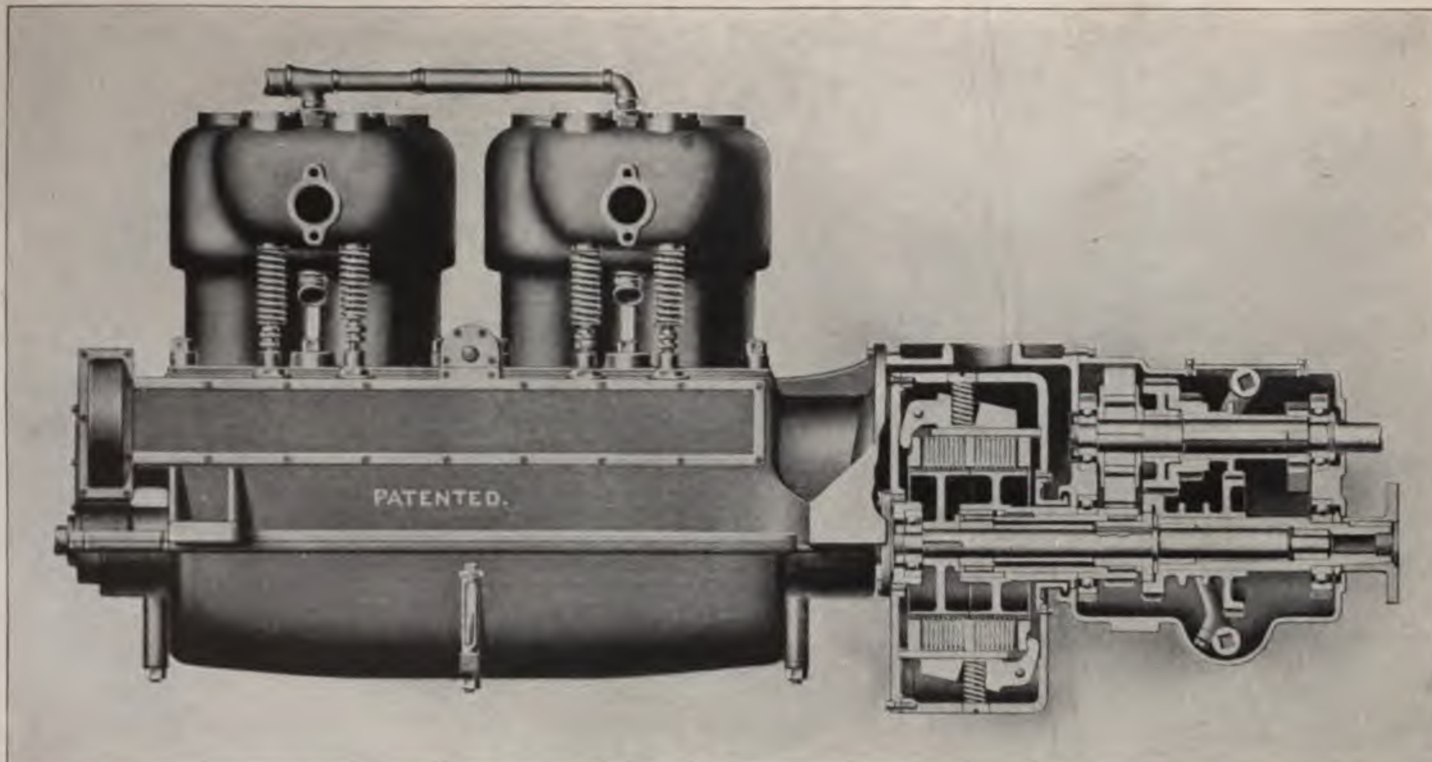
Automatic—Self-acting; operated by self-acting machinery.

Automatic Inlet Valve—An inlet valve worked atmospherically by the suction of the piston, as distinguished from the mechanically-operated valve. See Valves.

Automatic Valve—A valve which opens and shuts automatically by reason either of suction in front of it or pressure behind it, when such pressure equals the pressure of a spring tending to keep it closed.

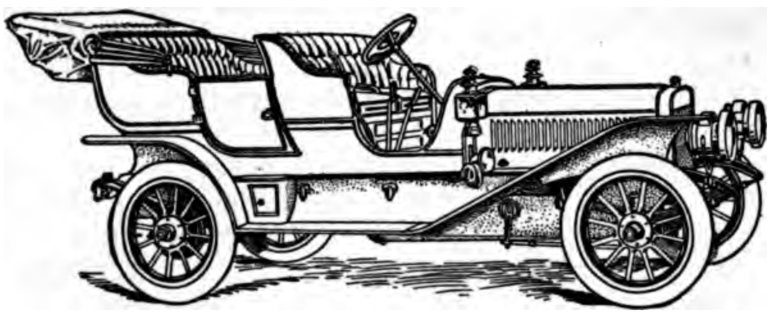
Auto-Trembler—See Coil.

Automobile—The name usually given in the United States to a self-propelled motor vehicle, the word meaning literally "self-moving"—Greek "autos," self, and Latin "mobilis," mobile. At first regarded with considerable misgiving, the word seems now to be fairly established in American usage, though the phrase "motor car" is preferred by many leaders in the trade, industry and pastime. "Motor car" is the term in general use in the trade on both sides of the Atlantic, while in the United States "automobile" is commonly used by the general public. For the purposes of this work, while the word "auto-



Latest Power Plant of the "Automatic" Automobile—40-50 H.P.

mobile" is generally used, the mechanical description of the various types of car in use will be found under Motor Cars, which see. See also Carriage Work, Gear and Gearing, Change Speed Gear, Driving, Internal Combustion Engine, etc.



"The Winton Six."

Automobiles for Doctors—See Doctors' Vehicles.

Automobiling—The use of the automobile; motoring.

Automobilism—The sport, pastime, industry and trade connected with the use of the automobile; fondness for the automobile; motoring.

Automobilist—One who drives or uses an automobile; a motorist.

Auto Truck—A self-propelled vehicle for the transportation of freight. See Commercial Cars.

Auxiliary Air Valve—An auxiliary air valve is sometimes provided to furnish an engine with more pure air on medium and high speeds. See illustration under Carbureter.

Aviation—The art or practice of navigating the air.

Aviator—One who navigates the air; an aeronaut.

Axis—The cylindrical portion of any mechanical piece intended to turn in bearings, as the axle of a wheel.

Axle—The pin or spindle on which a wheel revolves or which forms the axis of the wheel and revolves with it.

The term axle is applied to several appliances which, generally speaking, are all arranged to carry a load. An axle is

not necessarily fixed; sometimes it may revolve, as in a railway vehicle axle, but generally in automobile work the axle is a fixed member upon which the road wheels revolve. The front and rear axles of motor cars have, in addition to carrying the load, essentially different functions to perform. The rear axle has to provide for the transmitting mechanism by which the road wheels are rotated. The front axle has to provide for a turning movement of the wheels so as to change the direction of movement of the vehicle.

In automobiles of typical modern design the front axle, made of heavy forged steel, is usually bent down in front to clear the under side of the car engine or radiator. At its out-

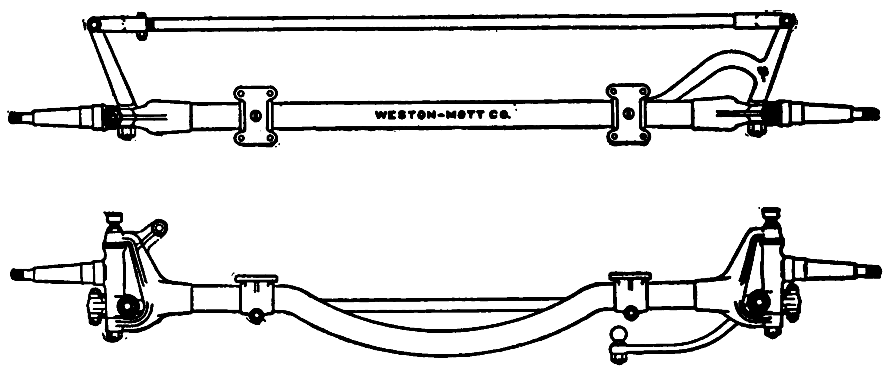


Fig. 1.—Tubular Front Axle.

side ends, and forged solid with it, are two nearly vertical pivots, and nearer the center are two flat lugs, forged with it and intended to take the springs supporting the car. At either end, swung on the pivots, are solid forged boxes, and on these and forged solid with them are the tapered forged steel wheel spindles on which the road wheels revolve. When in position the weight of the car rests on the bottom of these boxes, the bottoms of the pivots being recessed into the boxes with a big bearing surface to carry the load. The tops of the pivots are steadied and adjusted by the screwed steel caps, which are recessed in their ends and fit over the coned heads of the pivots. These caps allow of the adjustment of these bearings, and also

provide for their proper lubrication. The principle is the same as that used on old "ordinary" bicycles, and was originally known as the Stanley head. At the bottom of the boxes, and in one piece with them are lugs, into which are fitted the arms by which the steering boxes are rotated and which allow of the turning movement. See Steering Gear.

In principle all front axles are the same as this, only that variations in the method of mounting the wheel spindles are met with.

Rear axles may be divided into two types for the purposes of description—the fixed or dead axle and the live axle.

The fixed axle as used on cars with side chain transmission (see Motor Car) is very similar to the front axle we have described, with the exception that there is no provision for turning the wheel spindles, which are in one piece with the axle, and upon which the road wheels revolve. The latter are driven separately by chains from the differential countershaft.

The live axle is one which incorporates not only the means of supporting the car on the wheels, but also the differential and driving mechanism. It consists nearly always of a hollow tube fixed to the rear springs and incapable of revolving. Inside this tube run the two ends of the differential axle (see Balance Gear), and also in the center of the tube is contained the differential gear itself. Sometimes the road wheels are mounted direct on the ends of the differential axle or shaft, but in most modern practice the wheel hubs run on bearings outside the end of the tubular axle itself, and the differential shaft runs through the latter to the outside, and is there coupled to the end of the hub. This latter practice enables all the weight of the car to be taken by the fixed hollow axle, while no strain, except that of the transmission, comes on the differential shaft. In the former case the whole weight comes directly on the shaft, resulting in excessive friction and sometimes a straining of the shaft.

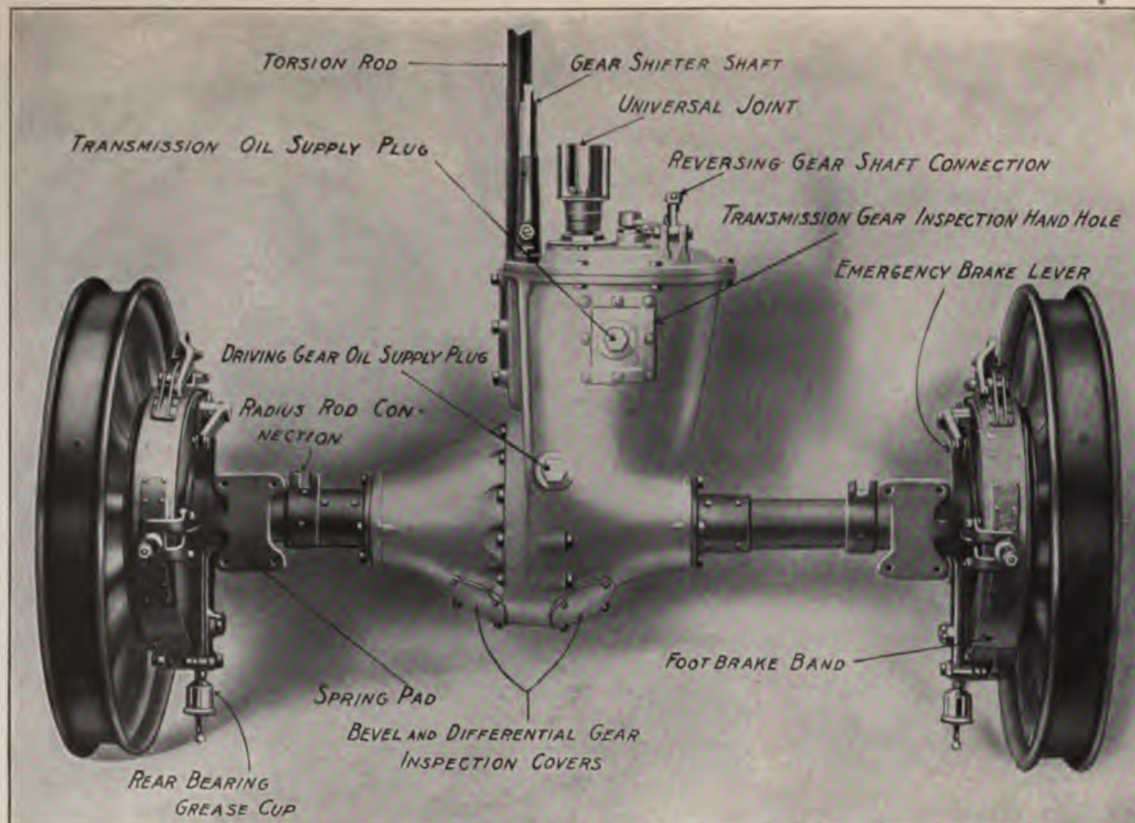
The cardan axle is a type which can almost be termed a live axle, and differs from the latter chiefly in that the differential gears and shafts are not inclosed in the tubular fixed

axle. It is called a cardan axle because it uses cardan or universal joints transversely to transmit the motion from the differential gear to the road wheels. The universal joint is a device introduced in the length of a shaft which is transmitting motion of rotation, and which nevertheless may have to bend slightly while working.

In the cardan axle used by the De Dion-Bouton Company of France a fixed steel axle, curved in a longitudinal plane, has at the two ends hollow straight extensions in the form of a straight tube. On the outside of these tubes the road wheel hubs are mounted to rotate, and they, of course, take the weight, just in the same way as the tubular member of the live axle which we have described. Through the center of these sleeves pass straight shafts, having at their inside ends two cardan joints. Their outside ends are provided with driving dogs or couplings, which engage with the ends of the wheel hubs and transmit the drive to them. The differential gear is inclosed in a gear box, which also contains the change-speed gear. This gear box is mounted on the frame of the car and quite independent of the rear axle, which can move up and down under the road shocks without affecting it. Two short shafts of the differential gear are connected with the straight shafts passing through the sleeves by two short cardan shafts and cardan joints. The body and springs are attached to the fixed axle by means of two lugs or plates. By this arrangement the rear axle is entirely independent of the differential gear, which is not carried upon it. In actual practice both the shafts, as well as the wheels, run on adjustable ball bearings.

Points of the Live Axle.

As the axle casing has to preserve the positions of both the driving bevel wheels and the balance gear wheels, it must be well designed, well constructed and not skimped in weight. In fact, the live axle, with its casing, is a delicate, though large piece of mechanism, and, in order to spare it in some degree, a good many makers avoid attaching the road wheels directly to the parts of the axle. Instead, they mount the road wheels on



The Packard Rear Axle Unit.

short, hollow, stationary axles, formed by extensions of the casing. The ends of the live axle and of the hubs project beyond the hollow axles, and are locked so as to rotate together, as by stars or carriers on the axle engaging in radial recesses in the outer face of the hubs. In this way the live axle serves to drive the wheels without being burdened with their weight. This is good so long as the locking device is strong enough.

This type of gearing scores on the points of neatness and its comparative immunity from the ravages of wet and grit, though the joints of the shaft should always be carefully incased and packed.

Front Axles and Steering.

Front axles differ considerably in the arrangement of the steering rods, and considerable attention has lately been devoted to this subject. It will be seen that except in very unique methods of construction it is necessary that the actual spindle on which the wheel revolves must overhang. Theoretically, the best effect would be obtained by pivoting the wheel spindle at a point central in the hub. This has been arranged for in one or two designs, but it has several disadvantages in actual practice, and has not been, to any extent, adopted.

The reason why the wheel should, theoretically, be pivoted at its center for turning purposes is that where it is overhung it is only kept straight, when in actual use on the road, by means of the links which connect the two wheels together and operate the steering. The result is that obstacles encountered by the wheel tend to turn it back on its steering axis. The same arrangement interferes with the easy steering of the vehicle, while, if the wheel is actually pivoted at its center, there is no tendency to divert the wheel when it meets an object full in front and the steering is much easier. Latterly, the same effect as is got by the center pivoting system has been obtained by canting the wheel over and by also inclining the axis of steering in such a manner that the axis cuts the ground line at a point coincident with the point at

which the wheel is theoretically in contact with the ground.

The difference between the two methods is shown in the diagrams, Figs. 2 and 3. In these diagrams the axis on which the wheel turns for steering is shown by the line A-B; the axis about which it turns for rolling on the ground is shown by the line C-D; the point of contact with the road is at E. It will be seen that if the axis A-B be produced to cut the ground line at F, the distance between F and E will represent the amount of leverage, tending to turn the wheel backward, which an obstacle would have.

If we now take diagram Fig. 3, we shall see that, by arranging the axes differently, we can get the same effect as

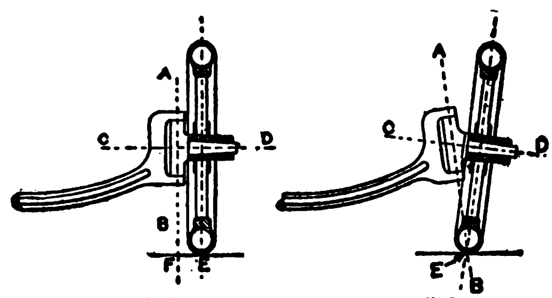


FIG. 2 STEERING AXLES. FIG. 3.

that which was got in the case of the method of steering where the axis of turning is in the center of the wheel. Here again the axis about which the wheel turns for steering is shown at A-B, while the axis about which it rolls is shown at C-D. The line A-B is produced to touch the ground line, and it will be seen that it coincides with the point E, which is the point of contact of the wheel with the road. It will thus be seen that the turning of the wheel about the axis A-B will not necessitate moving on the ground, except to turn on the theoretical contact point, and obstacles can exert no leverage tending to turn the wheel about the axis A-B. Of course, in this diagram Fig. 3, the angularity is considerably exaggerated. In actual practice this same effect can be got without so much difference between the angles which the

two axes make with each other in the two cases; that is to say, the angle can be nearer the angle as it is shown in Fig. 2, where the axes A-B and C-D cross each other at right angles.

The arrangement of the steering heads varies considerably, but in principle they may be divided into three classes, shown in Fig. 4.

(a) is the method formerly employed on heavy cars. The axle has a head forged on it bored out vertically with a slight

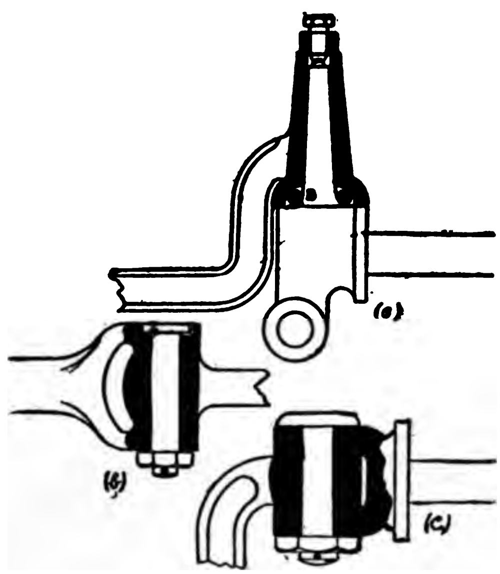


FIG. 4.—METHODS OF PIVOTING STEERING AXLES.

taper. The steering pivot takes the form of a vertical pin of corresponding taper, and fits the bore, the weight being taken either by a ball-bearing at B, or by a set pin in the crown of the axle. This method is specially good and safe for heavy cars, since it provides an ample bearing surface for the pivot, and nothing short of the fracture of an axle will disarrange it.

(b) is the practice often adopted on small cars and voiturettes. The axle is forked, and the steering pivot connected to it by a pin passing through both the steering axle's center

and the arms of the fork and locked at the bottom by a pinned nut. This method is also very good for light weights, but there are some old types, having ball cones top and bottom, and no pin, which are distinctly risky practice.

The third method, shown at (c), is that employed on the Mercedes cars, and in this case it is the steering axle that is forked, and the fixed axle that forms the center of the hinge. A pin passes through the pair. This method has been the subject of much comment, but has proved to be quite satisfactory.

Sometimes the axle is not in one piece, but is built up of channel steel, two pieces of channel steel being riveted back to back, and forming the axle proper, and the fork which carries the steering head being riveted to these. In a thoroughly up-to-date type of forked steering, the spindle carrying the two ball bearings of the wheel hub is a projection from, and in one piece with, a vertical cylindrical piece carrying at its top a ball bearing, as shown. This ball bearing comes between the top of the cylindrical sleeve and the underside of the top of the fork of the axle, so that the weight of the car is practically hung on it.

A central hardened pin runs right down through the two ends of the fork through the ball bearing and through the sleeve and holds the latter laterally, the pin being fixed by a lock nut at the bottom. This pin forms the bearing about which the wheel turns for steering purposes, while the ball bearing at the top takes the weight, acting as a thrust bearing and relieving the steering bearing of considerable friction. See Ball Bearings.

Types of Back Axles.

There has been a difference of opinion as to the efficiency of solid axles using chain drives direct from the wheels on the countershaft and those of the live type in which the power is transmitted by some form of bevel drive, and in which the shafts driving the wheel run inside the hollow axle which supports the weight. Owing to the difficulties of construction, failures in the latter type at one time were common, due

generally to the fact that it was necessary that the axle should be divided in at least one place (which greatly affected its strength), and also due to the dead load which it had to carry, that is to say, the weight of the bevel drive and the differential, which had to be taken directly by the tires without the interposition of the springs. So much attention, however, has been paid to the design of live axles in recent gears that these difficulties have practically been overcome.

At the same time, the solid axle with the chain drive has some advantages, namely, that the dead weight on the tire is not so great, and that the chain transmission is rather more elastic and conforms better to the varying positions of the back axle relatively to the frame. The previous objection to this type of transmission was the difficulty of keeping the chains in good order and adjustment, and also the noise. Both these difficulties have been got over by the use of efficient chain cases, so that the need for attention to chains is reduced to a minimum, they are well lubricated, and the noise has practically been eliminated. Quite distinctive are two axles which we refer to later, the De Dion, which retains the gear drive and yet puts no extra dead weight on the axle, and the Darracq, which puts the dead weight of gear box, bevel drive and differential on the solid axle.

Fixed Axles.

Where a chain drive is used—two chains transmitting the power from a countershaft (See Change Speed Gear) to sprocket wheels on the rear road wheels—the rear wheel is fixed, and is one solid piece. The wheels revolve on plain or ball bearings at its outside ends, and it has no part in the transmitting of the power to the wheels, simply carrying the weight of the car. It is generally forged of H-section steel and dropped down in the center so as to clear the body of the car.

Live Axles.

The type of axles in which the axle itself revolves, either inside or outside a fixed axle, are termed live axles to dis-

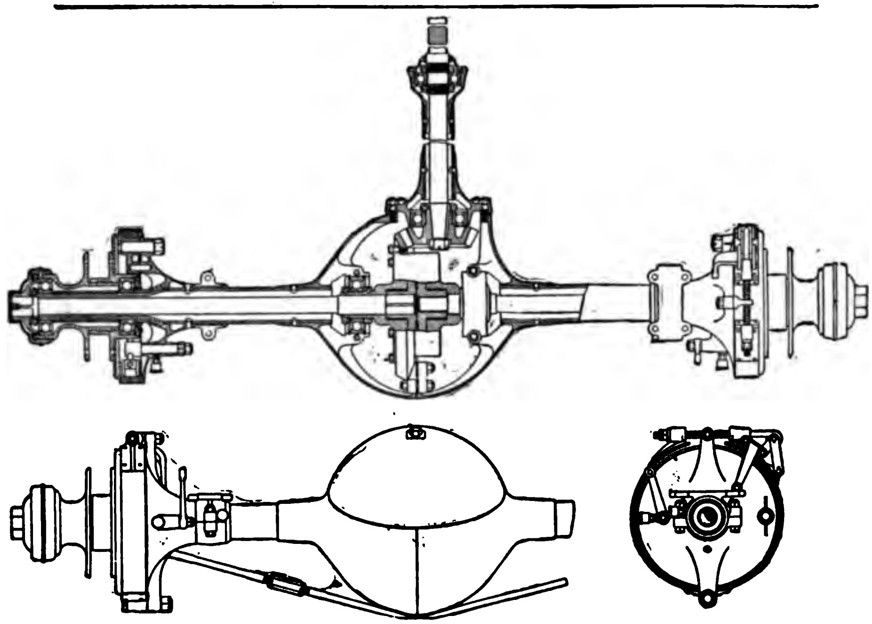
tinguish them from those types in which the wheels revolve on the outside of a fixed axle, as is the case where chain-driving is adopted. The live axle has become exceeding popular. It is almost universal in the case of cars of moderate weight, and is used in many really heavy cars. In most cases it incorporates in the mechanism the differential gear, which, where solid axles with chain-drive are used, is generally found included in the gear box mechanism.

Live axles may be divided into two types—those in which the driving axles run right through from the differential to the road wheels, and those in which the axle is articulated, as in the case of the De Dion.

In the axle of the Talbot car, which may be regarded as conforming to generally accepted practice, and built on the principle which underlies the construction of rear live axles, the actual driving member does not carry any load. The wheel hub contains a double ball bearing, which is fixed on the outside of a sleeve. This sleeve forms practically the fixed axle of the car, and it is upon this sleeve that the weight is carried. It runs right through from the ball bearings to the case which contains the differential and bevel drive, and it is continued similarly on the other side to the other hub. A brake is mounted upon it which carries the brake operating levers and the brake shoes, operated by a cam. The springs are attached to the axle at plates, one on either side. In order to prevent the axle sagging in the center, torsion rods attached to the bottom of the gear case and to brackets on either side are put in tension, and serve to support the center of the axle.

What we have described so far is all that is necessary to support the load and allow the car to run. The remaining mechanism, which we will now describe, is solely to transmit the engine power to the road wheels, and this is done by two shafts, known as the torsion shafts, because they carry no weight, but only have to transmit, torsionally, the driving strain. At either end they are octagonal in shape. At the differential end the octagonal end of the shaft enters into

pinions; at the hub end the octagonal end of the shaft enters the end of the hub, which is machined octagonal to fit. The drive is then transmitted from the shaft through a dog fitted on its end, and so to the hub. The dog is kept in position by an end plate or wheel cap. The power is applied by means of a long shaft supported on two rows of ball bearings, at either end of a propeller tube, a long tube which reaches right up from the differential to the universal joint at the back of



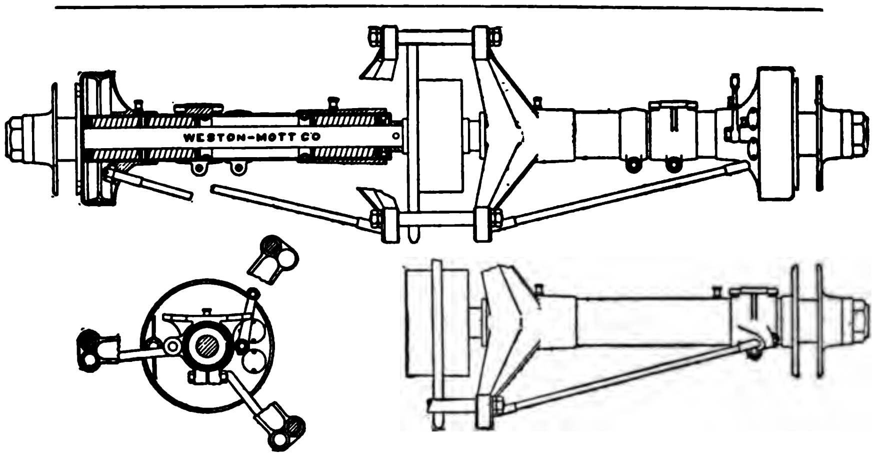
Bevel drive Rear Axle (Weston-Mott Co.) with annular bearings, as used in Stevens-Duryea 50 H. P. Cars.

the gear box, the universal joint being coupled to the shaft by the octagonal end of power shaft entering a similar shaped hole in the universal joint.

The shaft has at its end a bevel pinion which is in gear with a bevel crown wheel. This crown wheel is fixed to the outside of the differential member, and the rotation of the shaft rotates the crown wheel and the casing of the differential,

and drives the two road wheels round, owing to one of the planet wheels in the differential being in engagement with one of the pinions and also with another planet wheel in engagement with the other pinion. The ball bearings in the differential casing allow of the rotation of the differential box, and also of the shafts which transmit the engine power to the road wheels.

At the back of one of the bevel pinions a ball thrust bearing which takes the thrust caused by the bevel pinion and



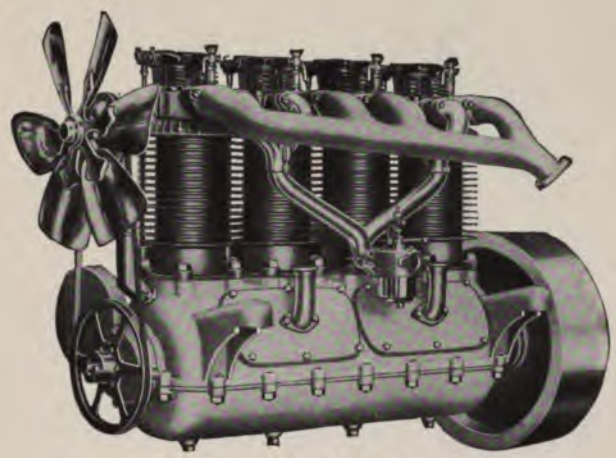
Rear Axle for Delivery Wagon (Hyatt roller bearings with ball thrust.)

the crown wheel trying to crowd out away from each other.

This can be regarded as a typical live axle as adopted on the majority of live axle cars.

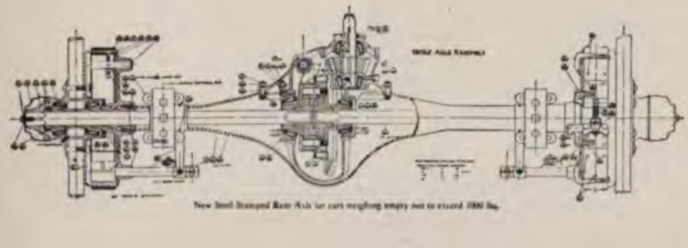
Cambered Axles.

Of late years it has become a practice of manufacturers to camber the road wheels; that is to say, to allow the road wheels to lie with their upper edges away from the car, instead of vertically, in a similar way to the cambering of cart and carriage wheels. In order to allow this, the construction is necessarily varied. An example of this is the S. C. A. T. axle, in which the axle is considerably cambered.



The Carrico Air-Cooled Engine.

Timken Roller-Bearing Axle.



New Steel Stamped Rear Axle for cars weighing empty not to exceed 3000 lbs.

In the case of some of these axles, while the axle is cambered and the wheel does not stand vertically, yet any of the spokes which are taking the weight will, as they come toward the bottom of the wheel, be in a vertical position. In order to get this result, the wheel has naturally to be dished; that is to say, the spokes have to be splayed outward. See Artillery Wheel under Wheels.

The Darracq Type of Axle.

An entirely different type of axle is the Darracq. In this case we have what is practically a combination of the live axle and the fixed solid axle; but there are other details in which it differs very considerably from the majority of axles. The solid steel axle is an H section girder dropped down in the center. At either end are brackets. The end of the axle is extended outward, and carries large ball bearings on which the driving wheels revolve and the springs are attached to plates on the brackets. These brackets also carry the pivots and operating levers for the internal expanding brakes.

An aluminum box is bolted down on to plates, forged solid with the axle, by means of four bolts, which pass completely through it. This box contains a change speed gear, the differential gear and the bevel drive, and the power is transmitted from the differential to the two road wheels by means of torsion shafts. These shafts pass from the gear box right through bearings in the ends of the solid axle, and at their outside ends they are provided with flanges of the same size as the flanges of the hub. Each flange is bolted up to the flange of the hub by the same bolts which hold the two sides of the hub together and hold the spokes in position. It is by means of these flanges that the power is transmitted from the shafts to the road wheels. The construction is such that if the flanges are unbolted from the flanges of the hub the shafts can be drawn out bodily endways, and then, by undoing the four bolts, the whole of the gear box, differential, and transmission mechanism can be removed in one piece.

The De Dion Type.

Another type of axle is the De Dion. The axle proper consists of curved steel tube, curved rearward directly at the back of the wheel centers. At each end of this curved axle are arranged brackets with extensions of the axle outwardly, these forming tubes on the outside of which the wheel hub runs. These two extensions of the fixed axle are slightly turned down—that is to say, they do not lie in the same plane, but allow of a camber on the wheels, the wheels inclining outwardly instead of standing vertically. The springs are attached to extensions of the axle, and are fixed to brackets on the chassis frame.

We will next describe the mechanism for transmitting the power from the engine to the wheels. A gear box also containing the differential is bolted to the chassis frame. It will be seen, therefore, that as the chassis frame rises and falls on the springs it will assume different positions relatively to the rigid axle, its weight being carried by the springs and the only dead weight on the tires being the wheels themselves and the solid axle.

As the gear box and the axle move relatively to each other, owing to differences in load and inequalities of road surface, it is necessary that the power transmitted from the differential gear in the gear box to the road wheels shall be transmitted by some flexible sort of coupling. This is done by the cardan shafts universally jointed at each end. They are universally jointed to the shafts of the differential, and at their other ends they are similarly jointed to shafts which pass through the hollow extension of the axle to the road wheels. The rise and fall of the gear box relatively to the axle will thus have no effect on the transmission, the cardan shafts allowing for the movement irrespective of the turning movement necessary for the drive.

The outside ends of the shafts through their universal joints, drive the shaft running inside the tubular extension of the axle, a ball thrust bearing being provided to take any end strain. The outside end of the axle is provided with a

dog, which engages with the end of the wheel hub, and so drives it.

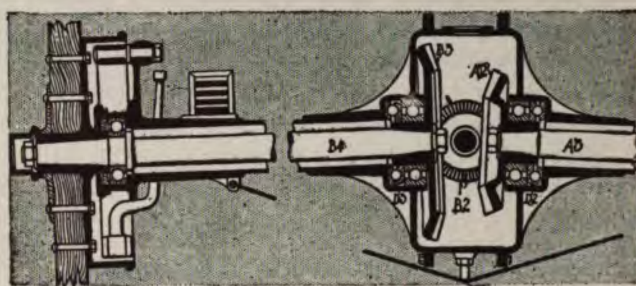
It will be seen that the feature of this axle is the fact that no more dead weight is carried on the tires than is necessary, and the dead weight of the gear box and differential is carried on the vehicle springs. The springs are so arranged that when the car is loaded with its normal load the cardan shafts will assume somewhere near a straight line with each other. This method of driving allows, of course, of the cambered wheels, and is a method used by the De Dion Company on all their cars, having been adopted on the very earliest types made by them.

The S. C. A. T. Rear Axle.

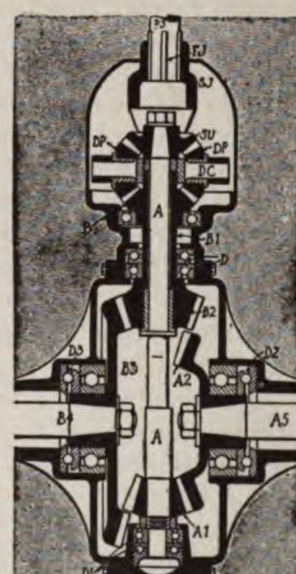
A novelty in rear axles recently exhibited in Europe is illustrated herewith. It is the S. C. A. T. axle, in which the differential is removed from the axle and carried in the driveshaft from the motor. The inventors urge the claim that placing it in the driveshaft permits of a stronger rear-axle construction, as well as providing increased clearance for the axle. The propeller shaft PS from the motor is feathered at its rear end FJ for sliding purposes in the universal joint SJ, this joint coupling with the differential cage. In the differential proper is a bevel gear SU, a taper fit on the end of the shaft A, which shaft extends rearward, carrying a bevel A1 in mesh with the larger bevel A2, that is, a taper fit on the end of the driveshaft, A3, coupling with the right rear wheel. Another bevel pinion B is carried on a sleeve B1, which has on its rear end a bevel B2, meshing with a large bevel gear B3, which is a taper fit, on the end of the driveshaft B4, which drives the left rear wheel. The differential pinions DP, two of which are shown, are carried on a cross DC, and are of conventional construction.

In operation, when the car is traveling straight ahead, the bevel SU on the shaft A and the bevel B on the sleeve B1 revolve at the same speed, and drive the axle shafts A3 and B4 at the same rotation, which is accomplished by making the

pinion B2 larger than A1, so as to accommodate them to their respective bevel gears B3 and A2, which are of unequal size, due to the design. When the wheels of the car revolve at dif-



SECTIONS OF S. C. A. T. REAR AXLE



ferent speeds, such as when turning a corner, the balancing effect is set up by the planet pinions DB in the identical fashion as if they were in the rear axle, but at which time the shaft A revolves either slower or faster than the sleeve B1.

One of the interesting parts in connection with this design is that the thrust between the bevels B2 and B3, is counteracted by the opposite thrust between the bevels A1 and A2, and by carrying the shaft A on annular bearings D and D1, at the front and rear respectively, the further alignment of the shaft A and the meshing of the bevels, is assured. End thrust ball bearings are used at the points D and D1, and also D2 and D3.

Another claimed advantage of this axle construction is that the shafts B4 and A3 can be arched, thereby giving the rear wheels the same camber as the front wheels.—Motor Age.

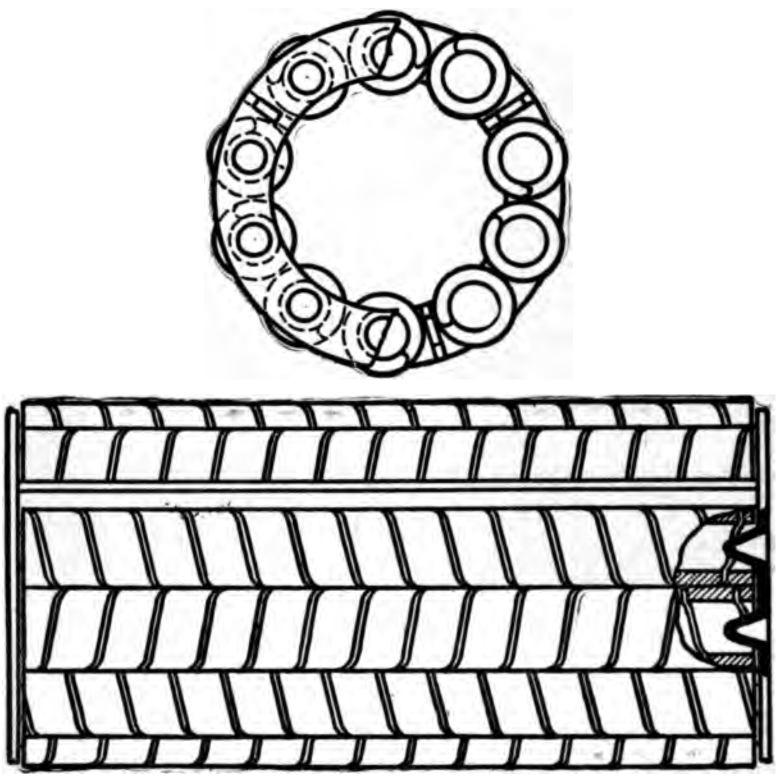
Axles and Bearings—The axles of the road wheels of a motor car are often round and solid, though occasionally made hollow to decrease weight and increase strength. On the most expensive cars, non-rotating axles are usually constructed of I section nickel steel, with the flanges horizontal and the web vertical. This is a very strong form, and light at the same time.

Three kinds of bearing are open to the car designer—plain, roller, and ball. In the first the contacting surfaces are very large, and absence of friction depends upon the maintenance of a film of oil between them. A well-constructed plain bearing, comprising a steel spindle turning in well-fitted bushes of some good brass alloy, will run freely and without undue wear for a long time; but it is difficult to readjust perfectly.

In roller bearings, the sliding contact is superseded by a rolling one, a series of steel cylinders being introduced be tween the shaft and the bearing case. The area of contact is reduced to a series of lines, and the number of lines is less than it might be owing to the necessity of keeping the rollers out of contact with each other. If the rollers were allowed to touch, they would tend to turn each other in opposite directions, and friction would be set up by the sliding line contacts.

The ball bearing retains its popularity and has the great merit that it lends itself to ready adjustment; but the fact that it only provides minimum areas of contact, namely, points,

makes it unsuitable for withstanding blows, as, for example, in the connecting rod bearings of the motor. Ball bearings are employed freely in the transmission gear and wheel hubs; but unless very well designed and accurately manufactured, they



New Self-contained Type of Hyatt Roller Bearings as used in Rear Axles, both chain and bevel drive.

are likely to do more harm than good, and should, therefore, be viewed with suspicion on low-priced cars. A broken ball not only sets up friction and injures the bearing surfaces, but is liable to cut into the axle itself, with disastrous results.

Every bearing must be lubricated in some way. A number are fed through pipes from the sight-feed lubricator on the

dashboard; the steering pin bearings and a few others are generally fitted with grease cups, the grease being forced into the bearing by a spring, the pressure of which is increased by screwing down the cap of the lubricator. Chains should be freely treated with a grease containing a liberal admixture of finely-powdered graphite.

Axle, Blind—A dead axle. See Axle above.

Axle-box—The journal of an axle or the bearing in which it revolves.

Axle Cap—See Axles.

Axle Casing—See Axles.

Axle, Dead—A fixed or non-rotating axle.

Axle, Floating—A live axle, or one which communicates power while floating, as it were, in the casing which supports the weight of the machine.

Axle, Floating, Broken or Bent—See Miscellaneous Roadside Repairs.

Axle Housing Parted—See Miscellaneous Roadside Repairs.

Axle, Live.—A driving-axle or one which revolves with the wheels.

Axle Sleeve—See Axles.

Axle, Solid, Broken—See Miscellaneous Roadside Repairs.

B

Babbitt Metal—An alloy of tin, copper and antimony, used for bearings.

Back Fire—A premature explosion in the cylinder of an internal combustion engine. It is usually caused by the gas being ignited before the piston is in the correct position for its working stroke, thus causing the piston to be driven in the reverse direction to that in which it should travel. A back fire generally takes place in starting a motor, when the sparking is too far advanced. It may result in a sprained wrist or other injury unless the operator holds the starting crank loosely in one hand, so that it can be dropped instantly should a back fire occur and cause the handle to rotate in the reverse direction. One quick sharp half turn is all that is generally necessary, and to wind the handle completely round as a rule increases the risk.

An explosion in the muffler is also called, but incorrectly, a back fire. It is caused by the ignition of unused gas. Defective sparking or faulty mixture is generally the cause. See Repairs and Adjustments.

Backfiring in the Carbureter—See under Irregular Missing.

Backing—The motion of a car on a grade, due to gravity.

Back-kick—The motion of a starting crank resulting from a back fire.

Backlash—The jarring reaction of each of a pair of wheels upon the other, produced by irregularities of velocity when the load is not constant or the moving power is not uniform; the play between a screw and its nut when the latter is loosely fitted.

Back Nut—See under Bolts and Nuts.

Back Pressure—The retarding influence caused by the exhaust gases on the piston during the exhaust stroke, when insufficient vent is given for their escape. From the aperture

of the exhaust valve to the pipe which admits the exhaust gases to the air, ample freedom must be given for a clear escape of the exhaust gases, as any opposition to their passage materially reduces the horse-power of the motor. These pipes, therefore, should be large and should have no acute angles. The muffler also should be so constructed as to admit of a reasonably rapid escape of the exploded charge. Some mufflers are designed so that the back pressure is even less than if the exhaust gases were ejected directly into the open air.

Back Pressure Valve—See Valves.

Bad Compression—See Repairs and Adjustments.

Baffle Plate—Any plate which serves to break up or change the direction of a current of heated gas or flame. The term is generally applied to the plates contained in the muffler, which serve to break up the exhaust gases from the motor and to reduce the sound they would otherwise make when passing to the air.

Balance—The balance of the high speed internal combustion engine has been one of the most difficult problems which the motor engineer has had to face. When we have heavy reciprocating parts moving at high speed, the resistance which their momentum sets up to the arresting of their movement at each end of the stroke is enormous, and can only be overcome either by very heavy design or by very careful balancing of the moving parts, so that their momentum acts in opposite directions and counteracts itself. Similarly, when we have a wheel or disk running at a high speed, and it has, on one of its edges, a weight which is not balanced by another at the opposite edge, an enormous swaying action is set up, which tends to cause abnormal and intermittent strains in the mechanism. In the case of the reciprocating parts this is overcome by making two moving parts of approximately the same weight move in opposite directions. Thus, in a twin-cylindered engine, the pistons are set to be always moving in opposite directions to each other. Complicated designs, such

as opposed cylinders and paired crank shafts, turning in opposite directions, have been used for this purpose.

Crank shafts are balanced by incorporating opposing bodies of metal in their construction, which will counterbalance the weight of the crank pins and partly of the connecting rods. The subject is highly technical, and is one for the consideration of the mechanical engineer rather than the automobilist.

Balance Crank—That form of crank which has a balance weight opposite to the crank itself. The weight should approximately balance the weight of the crank throw and the mass of the piston and connecting rod. It lessens the power lost in the stopping and re-starting of the piston at each end of its stroke.

Balance Gear—In turning a corner the wheels of an automobile must of necessity travel at different speeds, as the outer wheel has in the same time to travel through a much greater distance than the inner wheel. As the front wheels of the car are mounted independently on the axle, each adapts itself to the required speed. But to enable both rear wheels to be driven by the engine, and yet contrive that one wheel can travel faster than, or overrun the other in turning corners and (to a lesser degree) when departing from a perfectly straight line, the balance or differential gear is necessary. The driving axle or countershaft is made in two parts, joined together in the center by a balance gear of the description which was originally invented for traction engines, afterwards adopted for tricycles and since adopted for nearly all kinds of motor driving, except the single driving wheel of a bicycle and the single driving rear wheel of a tricar. See Gear, Differential.

The arrangement may be either fitted to the countershaft in the case of a car with side chain transmission, or in the case of a live axle car to the back axle itself, to enable the road wheels to vary their rate of revolution while the driving effort of the engine is being transmitted to both of them. In Fig. 1 an ordinary type of bevel differential is shown. A

and A1 are two large bevel gear wheels mounted on the inner ends of the live axle differential or torsion shaft, or on the inner ends of the countershaft. See Countershaft.

A1 is shown in section. Now, mounted on the outside ring C are two small bevel pinions B B which mesh with the other bevels A A1. From this it will be seen that if the outer ring C, which is driven from the engine by bevel or worm gear, is turned, it will take the two large bevels AA1 round with it by means of the smaller bevels B B, these not revolving on their own centers. This is equivalent to driving the car in a straight line, and both ends of the torsion shaft turn together and at

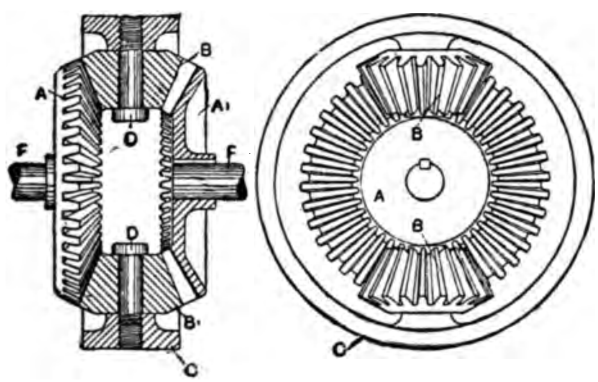


Fig. 1—Balance Gear.

the same rate. We will now suppose that, for some reason, such as rounding a corner, the bevel wheel A1 runs faster than A, this increased speed being due to the increased speed of the outside road wheel. Bearing in mind that the engine speed is kept constant, and therefore that the ring C revolves at a constant speed, it will be seen that the small bevels will begin to revolve on their own centers, due to the difference in speed of the larger bevel wheels, at the same time transmitting an equal drive to each, just as when driving in a straight line. The great point to be remembered when dealing with the differential is that the smaller bevels B B do not revolve when A and A1 are running at equal

speeds—i. e., when the car is running along a straight path. The outer ring may have either a bevel or a worm wheel attached to it to take the drive from the engine.

Another form of balance gear is that which has ordinary straight teeth cut gear wheels in place of the bevel pinions. The advantages of this type are that they are easier to manufacture, and set up no end thrust on any of the shafts. The action of the straight pinion bevel gear can be easily understood from Fig. 2, which is purely diagrammatic.

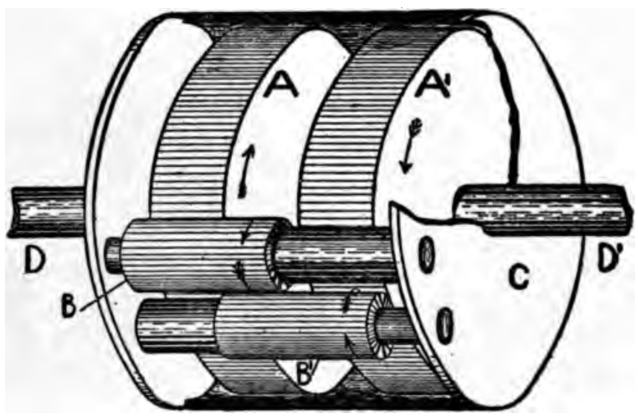


Fig. 2—Straight Toothed or Spur Balance Gear.

A and A1 are two straight cut gear wheels corresponding to the large bevels in Fig. 1. D and D1 are the torsion shafts on which they are mounted, communicating the drive to the road wheels on each side. This drive is taken from the engine by the outer case C, on which is mounted either a bevel wheel, chain sprocket, or worm wheel. See Motor Cars. Mounted on small shafts crossing the case C are ordinary gear wheels B B1, which mesh with each other, and also with the large gear wheels A A1. From this it will be seen that the drive is transmitted equally to the two shafts D D1 via the small gear wheels B B1, which do not revolve, but act as a kind of lock, locking the two gear wheels A and A1 together.

Now if one gear wheel runs faster than the other, due to

one road wheel over-running the other, the small gear wheels B B1 will simply revolve about one another, while at the same time transmitting the engine drive, the motion, in fact, being exactly similar to the bevel differential.

We will suppose, for instance, that the casing C, which takes the drive from the engine, is held stationary and the torsion shaft D1 rotated in the direction of the arrow on the wheel A1, then this wheel would drive wheel A in the opposite direction through the medium of the pinions B1 and B, these pinions rotating in the direction indicated by the arrows. A modification of this action is what takes place whenever the car is traveling on a curve, and the action is more pronounced the smaller the radius of the curve.

Balata—An elastic gum obtained from a tree of tropical America. It is intermediate in character between caoutchouc and gutta-percha and is used for belting and insulating purposes.

Balladeur Train—The French term for gearing of the Panhard type, in which change of gears is effected by sliding one train of toothed wheels along one of the shafts (these being prevented from revolving thereon by the shaft being squared or castellated, or by a feather), the sliding movement bringing the toothed wheels into engagement with those of another train of gear wheels. Different speeds are obtained according to the relative sizes of the wheels brought into mesh. See Change Speed Gear.

Ball Bearings—See Bearings.

Ball Race—The hardened steel path or groove on which the balls in a ball bearing run.

Ball and Socket Joint—Often used to connect up the links, arms, and levers of the steering gear. See Joints.

Balls, Steel—Hardened steel balls are used in a great number of motor bearings to reduce the friction. It is necessary that they should be truly spherical, that they should be capable of sustaining great crushing loads, and that their surfaces should be so hard as to be practically impervious

to wear. These requirements have been filled by the marvelous advances made in their method of manufacture. The manufacturers can now guarantee them to the ten-thousandth part of an inch, both as to diameter and sphericity. The wearing qualities of balls depend largely on the accuracy and design of the ball races in which they roll.

Ball Thrust Bearing—Where end pressure comes on a shaft the ordinary bearing on which it rotates is unsuitable to receive this pressure, which may be considerable. A ball thrust bearing is therefore arranged, generally between a collar on the rotating shaft and a shoulder on the member in which it rotates. Such bearings become necessary in the case of bevel-toothed wheels which have a tendency to crowd away from each other, and a ball bearing is generally interposed to take this end thrust. The same is the case with clutches; in order to prevent unnecessary friction when the clutch is held out of engagement against the pressure of the spring,. a ball thrust bearing is interposed. See Bearings.

Ball Valve—See Valves.

Band Brake—See Brakes.

Barking—The series of explosions resulting from after-firing.

Barrel—In mechanics, any cylindrical part of a structure.

Base Chamber or Crank Chamber—See Chamber.

Base, Wheel—The distance from the center of a front wheel of a car to the center of a rear wheel on the same side, usually measured in inches.

Battery—A number of voltaic cells arranged together so as to give a more or less powerful current of electricity.

Batteries are of two kinds, primary and secondary, the latter being usually termed a storage battery or accumulator.

Primary Batteries are those in which a current of electricity is generated by chemical action between two dissimilar elements, such as zinc and carbon, or zinc and copper. The pressure or voltage of a primary battery cell is a definite fixed quantity for any particular type. For instance, the zinc,

carbon and sal ammoniac battery has a voltage of 1.6 per cell, while the zinc, carbon and chromic acid battery has a voltage of 1.8 per cell. The current which any primary battery gives is not a fixed quantity, but depends upon the resistance of the particular circuit through which the pressure in volts propels the current. This resistance consists of, first, the internal resistance of the primary battery itself, and secondly, the external resistance of the outer circuit, such as the primary winding of the induction coil or the resistance of the filament of a small electric lamp. Therefore, the amount of current which can be obtained from a primary battery depends upon its condition with regard to internal resistance, and also, the amount of resistance of the external circuit.

In automobile work, the type of primary battery in common use is based on the principles of the Leclanché cell, which is a distinct type, in which the current is obtained by the chemical action between a zinc and carbon plate immersed in sal ammoniac. The carbon plate is also surrounded by a mixture of material called manganese dioxid, which has the property of absorbing oxygen from the surrounding air. It is this property which makes a Leclanché battery extremely efficient for intermittent work, as the battery replenishes itself with oxygen from the air when at rest.

All forms of dry primary batteries are based on this principle, the sal ammoniac solution being contained in some absorbent material to avoid spilling, which would occur if it were used in liquid form.

This method of using the battery in a dry state has the disadvantage of increasing the internal resistance, and in course of time rendering it useless.

Types of Leclanché cells, having a liquid sal ammoniac solution have been introduced for automobiles, and these may avoid many of the disadvantages of the dry type. The electromotive force or voltage of one Leclanché cell is 1.6, and is the same in all types of dry cells which are made on the same principle. Four of these cells are usually grouped

together, giving a total voltage of 6.4 volts, which is quickly reduced to about 5 volts when a current is taken from the cell.

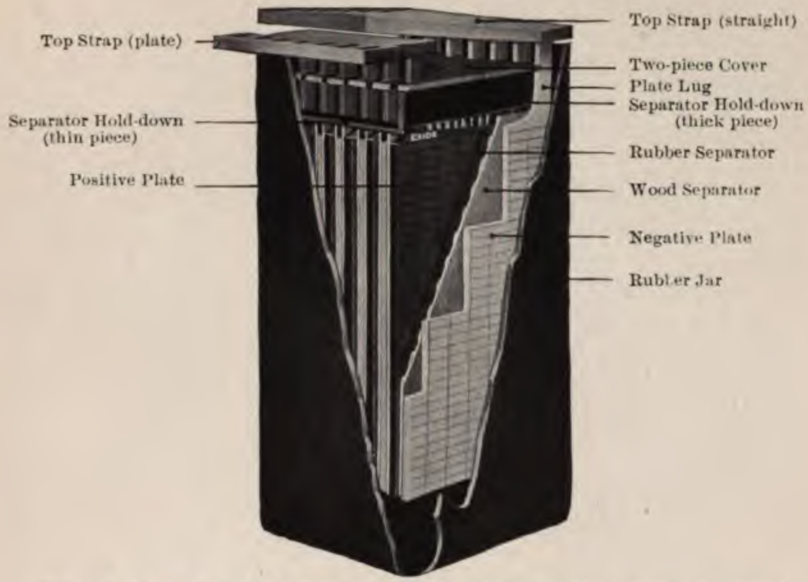
It is possible to obtain a very high current from one of these batteries when it is short circuited, but this is a very misleading method of gauging the strength, as the voltage of the cell has only to drive the current through its own internal resistance, and is not doing any outside work. Moreover, the battery would only give this high current for a few moments, as the voltage will rapidly fall at the excessive rate of discharge.

Dry cells cannot be recharged when once they are run down, but they may often be temporarily restored to usefulness when apparently discharged by the addition of a strong solution of sal ammoniac.

The Storage Battery.

The Secondary Battery, accumulator or storage battery, differs entirely from the primary battery inasmuch as it is an arrangement of lead plates contained in an acid solution, which are only in a condition to give an electric current after they have been brought to a proper chemical state enabling them to do so. Practically, it is necessary to charge the accumulator with a current of electricity, which can be taken from the accumulator again when required. Theoretically, the charge of electricity produces a condition of chemical activity on the two plates which brings the battery to the same state as a primary battery, in which state it will give back the current which has been put into it, with the exception of certain loss due to the process.

When the storage battery is in a charged state, it has a certain fixed pressure at its terminals, which will send a current of electricity through any conductor connected to the two terminals, the strength of this current depending entirely upon the amount of resistance in the conductor or circuit which is connected across the terminals. Therefore any conductor, such as damp or acid moisture, or dust in which any conducting substance is present, will allow a current to



"Exide" Sparking Cell Equipped with Top or High-burned Straps, Showing Details of Assembling.
(The Electric Storage Battery Co., Philadelphia.)

Phantom View of an "Exide" Sparking Battery.

escape across the top of the battery from one terminal to another. The battery terminals should, therefore, be kept clean, or protected from such leakage.

It should be understood that the accumulator stores energy, not electricity. When the electric current decomposes the water of the electrolyte, and causes an oxid of lead to be formed on one of the plates, a certain amount of energy is stored up. There exists a strong tendency for the lead plate to resume its normal condition by undoing the previous process, and when the circuit is completed between the poles the oxid of lead is decomposed, and, as a result of this chemical action, an electric current flows. In charging a cell electricity is, so to speak, converted into chemical energy, and in discharging the cell this chemical energy is transformed into an electric current.

It was found that by constantly charging and recharging in alternate direction, the capacity of the cell was much increased, and this process, which was repeated until the maximum capacity was reached, was known as "forming" the cell. The discovery has since been greatly elaborated, both by the original inventor and by others.

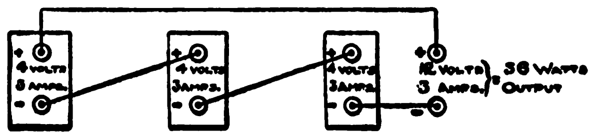
Methods of Coupling up Batteries.

Two or more batteries may be coupled together in order to give increased pressure of current (voltage) or increased volume of current (amperage). The two methods of coupling up are termed respectively "in series" and "in parallel."

When coupling up batteries in series we so arrange the connections between them that the current flows right through all the batteries in serial form, so that the current generated in No. 1 battery of three units must pass through the other two before a circuit can be formed. The positive terminal of one must be connected to the negative terminal of the next, and so on throughout the battery. This is shown in the illustration.

Here we have three cells coupled in series. Each has a

pressure of 4 volts, and the resultant pressure available for sending a current through the circuit amounts to 12 volts. The maximum discharge rate of the circuit remains the same,

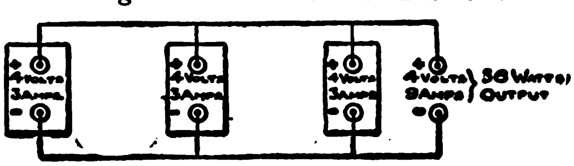


Coupling Cells in Series.

but the 12 volts pressure enables this current to be obtained through a greater external resistance.

The use which the automobilist will generally make of the possibilities of coupling up batteries will be to get a higher voltage for two batteries which have run down too low for efficient ignition. When this is the case, by coupling them in series, the voltage of the two combined may be sufficient for ignition purposes. It must be remembered, however, that this is only a temporary expedient, and when accumulators have got much below 4 volts for a double cell they will rapidly run out. This is not so much the case with dry batteries, which run out more slowly and can be coupled up in series with better results than is the case with accumulators on account of the internal resistance being high.

When coupling up batteries in parallel we so arrange the connection between them that the current may flow through any of them or all of them. In this case all the positive terminals are connected together, and all the negative terminals are connected together. This is shown below.



Coupling Cells in Parallel.

Here we have the same cells coupled in parallel. The pressure of each cell—namely, 4 volts—is not added, but the total pressure of the three cells connected in this way remains

at 4 volts. The maximum discharge rate of the circuit is, however, trebled, as each battery is able to discharge its separate supply of current to the circuit, and the three batteries have become like one large 4 volt battery with three times the number of plates in it. Therefore a current of 9 amperes can be taken from the cells, if the 4 volts pressure available are sufficient to carry this current through the resistance of the external circuit.

Accumulators are usually charged in series, in order that the same amount of current may flow through them. If accumulators are connected in parallel, and the circuit of one is broken, the others would receive the extra current from the broken circuit, and there would be no indication on the meter that anything was wrong.

When batteries are charged in series the voltage at their terminals may differ, but the current through each one is the same.

When batteries are charged in parallel, the voltage at their terminals is the same but the current through each may differ.

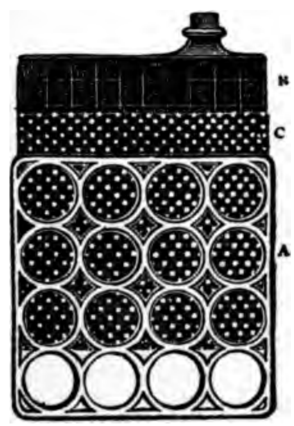
Types of Storage Batteries.

The numbers of different batteries now on the market may be classified into two types—the Planté and the Faure. In the former, plates composed of spongy or porous lead are used, and in the latter the plates are stamped or otherwise shaped with recesses, into which apertures suitable compounds of lead are artificially forced. The object of this is both to reduce the weight and to expose a greater surface to the charging current, and it is on the shape of the retaining grids and the methods by which the paste of the plumbic compounds is retained that the various patents relating to storage batteries are based, since the fundamental principles are in all cases identical.

One type of grid for holding the peroxid of lead compounds consists of a kind of double latticework cage forming an envelope in which the lead oxid paste is firmly held in position, and the conformation of the grids is such

that the whole mass forms an undivided plate in the interior so that it is difficult for the material to be knocked out. At the same time it presents a remarkably large surface to the action of the acid.

In another type, which has the same object in view, the plate is in the form of a pasted grid, which is inclosed in an outer case or armoring, while a sheet of perforated celluloid is slipped in between the plate and the armor case on each side. In this way no loose pieces of material can fall out,



Storage Cell, Partly Assembled.

A, Celluloid Cage; B, Plate Loaded with Lead Oxid Paste; C, Perforated Case Inclosed in Cage A.

while the acid has free access to the plates and the whole plate is strengthened by the outer case.

Many efforts have been and are being made to substitute some other metal for lead, the fundamental base of the storage battery, but great difficulty has been experienced.

Charging Batteries.

If there is an electrical supply available, accumulators can be charged from this source, provided that the system of supply is what is called continuous current, that is to say, that it flows in one direction, not in alternate directions as so many systems do. This can be ascertained by inquiry at

the supply company's station, or by testing with a piece of pole-finding or litmus paper, as described later. In any case, those who have little or no knowledge of electric light circuits should be very careful when interfering with them, as on a 200-volt circuit very unpleasant shocks can be obtained, while tampering with switches and other parts of wiring circuits may result in flashes, melting of fuses, and bad contacts, with consequent fires at a later period. It is, therefore, advisable to obtain the assistance of an electrician to make a safe and convenient arrangement from which the battery can be charged without risk.

The following are suitable for the purpose:—

From a Switch—Charging from a switch which is in series with 1, 2, or 3 lights which it controls. In this case have a small block with two brass terminals fitted under the switch and connect wires from the switch terminals to the block terminals; test which is positive and negative with pole-testing paper, and mark them permanently for use. When the switch is off and the battery connected to the charging block terminals, the current for the lamps will pass through the battery instead of passing across the switch bar. Care must be taken not to turn the switch on when the battery is charging, or it will be short circuited by the switch bar joining its terminal wires. To guard against an accident of this sort, instruct the electrician to put a small fuse in the charging block circuit.

From a Lamp Holder—Charging from a lamp holder in an electric light pendant or bracket is another method. For this purpose it is necessary to purchase from an auto supply house a very convenient little arrangement called a Charging Adapter, which consists of a lamp holder socket arranged with a pair of wires in series with the lamp, to connect to the accumulator. To use this remove the lamp from a pendant, and place the adapter in its place (it is made to fit any holder), insert the lamp in the holder, with which the adapter is provided, and connect the battery to the two wires, after you have tested which is positive and which is negative.

To Test the Poles With Pole-finding Paper—Moisten a slip of paper at one end, and hold the two wires at a distance of one-half inch or so apart. If there is a circuit the negative wire at once makes a crimson spot on the paper. Note this is negative and the other wire positive, and join up the accumulator, negative wire to negative terminal, and positive wire to positive terminal. The lamp lights up and the current is then passing first through the lamp and then through the accumulator in series.

To determine amount of current, use lamp as follows:

100 Volt Circuits—For ½ ampere use one 16 c.p. lamp; 1 ampere, 32 c.p. lamp; 1½ ampere, 50 c.p. lamp.

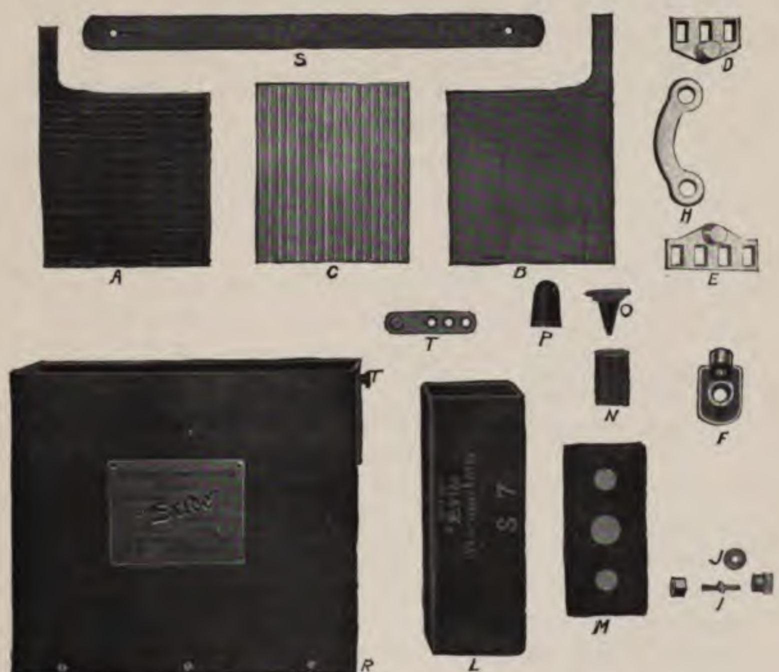
200 Volt Circuits or More—For ½ ampere use one 32 c.p. lamp; 1 ampere, 50 c.p. lamp; 1½ ampere, 100 c.p. lamp.

For higher currents than 1½ amperes it is wasteful and expensive to recharge in this way.

The time taken for charging depends altogether on circumstances; 5 to 6 hours is generally sufficient, but no harm is done by leaving them on all night. A brisk ebullition of gas from the plates indicates that the cell is fully charged.

There is no simpler method of testing which pole is positive and which is negative than by the use of pole-finding or litmus paper, and as this is easily obtained from any electrician a small amount of it should be in every automobilist's kit. Should it be impossible to obtain any, the correct method of connecting up the battery when it is to be charged in series with a lamp can be determined by the following method: When the battery is joined to the correct wires for charging, it will make a slight diminution in the brilliancy of the incandescent lamp, and if it is joined up in the wrong direction, it will increase the light. It is, therefore, easy to judge by the eye if the light of the lamp is greater or less when the battery is joined up, and take care that it is always connected so that the light is less.

The use of the incandescent lamp in the circuit is for the purpose of making sure that only a small current passes through the battery, as, supposing the battery was connected



The 1909 Model "Exide" Sparking Battery in Detail.
(The Electric Storage Battery Co., Philadelphia.)

A—Positive Plate
B—Negative Plate
C—Wood Separator
D—Positive Strap
E—Negative Strap
F—Terminal Lug
H—Side-by-Side Connector
I—Terminal Bolt Connector, Stud, Thumb Nut and Hexagon Nut
J—Copper Washer for Bolt Connector
L—Hard Rubber Jar
M—Hard Rubber Cover
N—Hard Rubber Cylinder Vent
O—Vent Plug for Cylinder Vent
P—Soft Rubber Cap
R—Wood Case
S—Strap Handle
T—Fitting for Strap Handle

right across the supply wires, it would receive the full pressure of the current, and would probably be blown to pieces, unless a fuse saved it. With a lamp in series with it, however, only a small proportion of the voltage is found to be across the battery terminals if tested with a voltmeter, and it is impossible for the battery to receive more current than the lamp is taking, this being quite safe.

Accumulators can also be charged from primary batteries, which is an expensive but sometimes very convenient method of charging, or they can be charged from dynamos working private installations at factories, etc., in which case the same conditions apply as in charging from supply mains. It is also possible to charge them from a few of the large lighting accumulators in private installations, where the electrician in charge would do all that was necessary.

Always clean the terminals and top of the cells after charging, and wash them if there is much acid spray on them. Remove the vents before charging.

If, when cells are being charged, an ebullition or boiling can be observed in the electrolyte, it is a certain indication that either the cells are fully charged, or are being charged too rapidly, since the plate is unable to absorb the oxygen quickly enough in the formation of peroxid. In charging also, as the operation proceeds the plates are able to absorb less of the product of the electrolysis than formerly, and consequently it is well to reduce the current.

A storage battery, when properly "formed" and charged, should show a voltage of at least 2.2 volts for each cell, and may go as high as 2.5. That is to say, the accumulators used on a motor vehicle for ignition purposes, consisting usually of a battery of two cells, should show, when freshly charged, anything from 4.5 to 5 volts, and these accumulators should never be allowed to drop below a voltage of 3.8, or injury to the plates will result. As a matter of fact, however, they can never be relied upon to give good results after the voltage has dropped below 4. The results may be improved by bringing the wires of the sparking plug a little closer together as

the battery runs down. Cells are never at their best when new, and continued charging and discharging improve the capacity immensely. The color also becomes darker on continued use.

Facilities for charging automobile batteries are now provided by all well-equipped public garages, but it is well for all owners and operators to familiarize themselves with the best methods of charging their batteries in an emergency, or when far removed from their usual facilities.

Ignition systems of a very complete character, including a charging outfit, are frequently fitted to modern automobiles. With the best of them uniformity of voltage may be secured and the system never runs out of current. A dynamo, run by the flywheel of the engine, charges the battery and keeps it always full of current of even voltage, for ignition and lighting work.

When to Charge Up Batteries.

When the usually deep chocolate-colored positive plate of an accumulator begins to look as though a very fine sprinkling of flour has been made on its surface, then it should be tested. Usually, when this condition is presented, a four-volt battery will register 3.8 volts on the voltmeter, and it is not safe to risk running longer, but the battery should immediately be recharged and care taken that the plates are completely covered with acid.

Battery Treatment.

No car owner, if he values his own comfort, should be without one or two spare batteries. And what is more, he should see that they are kept charged. It is a good practice to carry two sets of batteries connected up to a two-way switch marked No. 1 and No. 2 respectively, so that the driver may always know off which set he is firing. The spare set should be switched in from time to time just to encourage them, but no battery should be allowed to stand for more than a fortnight without having current drawn from it. Also any battery left standing for any length of time should have the terminals

smeared with a little vaseline, which will prevent sulphating and difficulty in getting the terminal screws undone when the battery is required.

Exhausted Batteries.

One of the most misleading and unaccountable faults which may happen, and which the novice may encounter on the road and have trouble in locating, is that due to using a battery which is almost exhausted. Such a battery will give just sufficient current to enable the motor to be started readily, and will run it without misfiring, but immediately the engine is put to drive the car by letting in the clutch the engine slows down and stops. On fitting a newly-charged battery the trouble is at once remedied. The cause of stoppage very much resembles that caused by the failure, temporary or otherwise, of the gasolene supply to the carbureter, only in this latter case some popping in the carbureter will be heard before the engine finally stops.

When a battery or accumulator becomes run down to such an extent as to refuse to produce a spark, an ignition spark of sufficient power may often be obtained by setting a passenger to vibrate the trembler with the fingers. Such a method has been found sufficient to run the car a distance of a mile or two.

Idle Battery Troubles.

When a battery has been standing idle for any length of time, although it may show four volts and even slightly over when tested by a voltmeter, it is not safe to assume that it will work in a reliable manner when desired for ignition purposes to run a motor. The voltage of a battery may appear to be fairly high after a rest, and yet immediately a small amount of current, such as is used by an induction coil, is required from it, the voltage drops down below 3.8, and this is insufficient to work an ordinary ignition coil. With such a battery the engine will start up readily enough and will run for a matter of twenty seconds or so; then the engine speed will gradually decrease, and ultimately the engine will stop. After a few moments' rest the engine can be again started,

with similar results. The novice is rather inclined to think that this shows that the battery is in good working condition, and that the trouble lies with the gasolene supply. The symptoms, however, are different, for with an insufficient gasolene supply, in addition to slowing up and stopping of the motor, there is also always a back firing in the carbureter.

Electrolyte Evaporation.

When the electrolyte, or liquid, in an accumulator cell falls below the level of the plates by reason of evaporation, fill up with a little clean soft water, distilled if possible. Further additions of sulphuric acid are not required. Never allow the solution to get beyond a quarter of an inch below the top of the plates; it may cause them to buckle. If for any purpose the acid solution is emptied from the cells, fill them up with water to prevent the plates sulphating.

Sulphating.

A trouble found largely with neglected accumulators is "Sulphating." This is a formation of white pimples and spots on the plates, or the entire coating of a plate with a film of white material. It is due to local action between the lead frames of the plates and the peroxid paste when the battery is left uncharged, and is sometimes very difficult to remove, except with great patience. When plates are badly sulphated, it is best to rinse out the acid and at the same time any loose pieces which may be causing the trouble, then refill the cells with acid of much weaker specific gravity, say 1.500. Then charge the battery at a low rate of current for a very long time until the plates regain their proper appearance. The acid can be changed finally for the right strength, and charging continued at the usual rate. Plates which will not regain their color by this means should be taken out and scraped.

The Acid.

The specific gravity of the acid used in storage batteries should lie between 1.150 to 1.250, though the density will

The Combat Igniter—Storage Battery.

Globe Steel Tool and Battery Box.

vary according to whether the cells are charged or not. Sulphuric acid of the purest quality only should be used, and distilled water, which can be had from any druggist, employed for making up the diluted acid. In case of emergency rain water can be used, but it is not recommended. An idea of the proportion of acid and water (by volume) necessary for the correct strength may be obtained from the fact that a solution having 5 parts of water to one part of acid has a specific gravity of 1.200, which is about the right strength of acid for a charged battery. Great care should be taken regarding the purity of the acid, as failure is inevitable with crude and impure electrolyte.

Care of Battery.

The satisfactory working of an accumulator depends to a large extent on the care which is taken with this most important part of the ignition circuit.

Always keep the terminals and the top of the battery scrupulously clean and dry, and protect those parts of the terminals which are not required to make metallic contact with the wires by coating them with pure vaseline. See that the rubber corks which are in the vents, or the vents of any other pattern which may be used, are kept free; that is to say, do not let the air holes get stopped up, or the result will be bursting of the case owing to the gases not escaping.

If the terminals are attacked by corrosion clean them with a little warm water and ammonia, and never leave terminals to continue to corrode, or they will be entirely destroyed. Keep the level of the liquid in the cells just over the tops of the plates and not up to or over the lead bars.

If any liquid is spilled fill up with more dilute acid, but if it has lost its volume by evaporation, fill up with distilled water. When a battery is likely to be out of use for some time, say two months, remove the wires and place the battery in a dry place, after cleaning and charging it, and covering all terminals and bridge connections with vaseline.

If there is a deposit of sediment, or any loose pieces in

the battery rinse them out, and always keep the spaces between the plates clear. Generally speaking, do not neglect the battery, but give it proper attention, and when it is sent away to be recharged see that the agent knows how to charge properly.

Some batteries are filled with the acid in a jelly form. This is a composition of silicate of soda (sometimes called water glass) which is mixed with the acid to make a jelly and prevent splashing and spilling. With this type see that a little moisture is always present on top of the jelly (water will do), as charging gradually evaporates the water in the cell, which must be replenished. Also see that the vents are not filled up with small pieces of the jelly, and always remove the vent corks when charging.

When an accumulator or battery is first put into use it is best to take off the terminal nuts and then wax or vaseline the screw-thread and put back the nuts. On connecting up the wires, see that a clean connection is obtained between the terminal face and the wire contact. The reason for this is that any acid liquid or vapor may corrode the brass thread and nut and so prevent easy removal when a fresh-charged battery is required. Whenever a terminal screw is found sulphated fast to a terminal so that it cannot readily be unscrewed with the fingers, never use the cold pliers and try to unscrew by exerting extra force. Make the pliers fairly hot, and grip the screw with them for some little time till it and the terminal are heated through. The screw will then turn and come away quite easily. If the terminal and screws are well smeared with vaseline before being screwed up there will be little trouble from sulphating.

Renewing Dry Batteries.

When dry batteries appear to be run down, holes should be made in the paste, as by pushing a screwdriver or rod down into it. As many holes as possible should be made, and these holes filled up with water, or, better still, muriatic acid. As the acid is a poison it must be handled carefully. A cell

discarded when showing only three amperes, and after treating it as above it gave twenty amperes. By filling the cell with water the amperage may be brought up to ten, and with good cider vinegar to fifteen. Probably the reason why adding these solutions again excites the battery is that they wet the paste, which has become dry, and so the internal battery resistance rises too high to allow a fair current to flow in the circuit.

Increasing Voltage.

The following plan of increasing voltage at will has been found of value. A 1½ volt dry cell is arranged in connection with the four-volt accumulator or battery, as in the diagram.

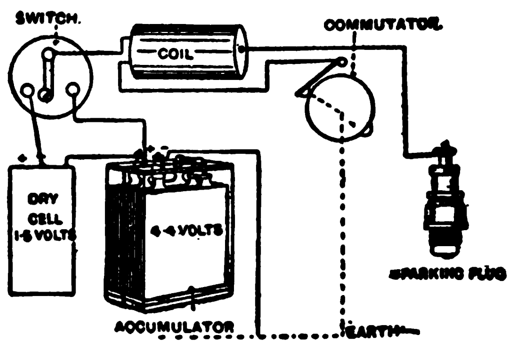


Diagram showing how to connect a dry battery with an accumulator for increasing the current.

For ordinary running the four volts are used. When required this current is converted into 5½ volts by altering the switch. The result is increased power for hill-climbing, etc., on top speed. The method is economical, as, if little used, the dry cell will last for months, and there is little or no danger of damaging the coil.

Fitting New Batteries.

Those who have occasion to fit new storage cells on their cars should remember that their choice should be influenced by the make of coil used. No battery should ever be discharged at a greater rate than one-tenth of its capacity; one-fifteenth

will give better results. By connecting up an ammeter (if not already fitted) in the primary circuit, and running the engine, the average current taken by the coil can readily be found. Suppose this to be 2.5 ampères, the capacity of the battery should not be less than about thirty-five to forty ampère-hours. Where a twenty-ampère hour battery is used, the discharge rate would be abnormally high, and it would only give, say fifteen ampère-hours. Further, its life would be shortened, and the plates would in all probability rapidly become buckled and distorted. When a plate expands, owing to the heat generated by a heavy current, the pellets become loose in the lead grid, and ultimately break and fall out. A safe rule is: Use the largest storage batteries that can conveniently be carried.

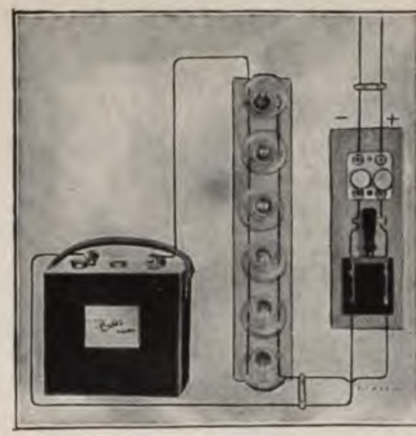
Battery Charging.

When lamp resistance is used for charging storage batteries the resistance board should have at least three lamp-holders. The lamps used should be of different candle-powers. To take an example, suppose the supply to be at a pressure of one hundred volts, a 32 c.p. lamp will take about one ampère. Suppose three of these are used. By employing one or more, the current can be given three values, namely, one, two, or three ampères.

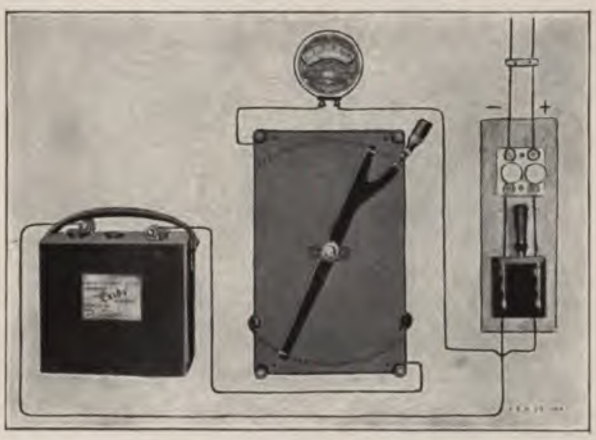
If three lamps of varying powers are used, the current can be controlled to a much greater extent. A 16 c.p. lamp will take about half an ampère, a 32 c.p. one ampère, and a 50 c.p. one and a half ampères. With these three lamps, the following currents can be obtained.

Using 16 c.p. lamp only............	½ ampère
" 32 c.p. lamp only............	1 ampère
" 50 c.p. lamp only............	1½ ampère
" 16 c.p. and 32 c.p.............	1½ ampères
" 16 c.p. and 50 c.p............	2 ampères
" 32 c.p. and 50 c.p...........	2½ ampères
" 16, 32 and 50 c.p...........	3 ampéres

If an 8 c.p. lamp be also kept at hand, the current can be



Charging Through Lamps.



Charging Through Rheostat.

Charging Storage Battery from a Direct Current Lighting System.

The simplest method of charging is from an incandescent light circuit, using lamps connected in parallel to reduce the voltage to that of the battery, the current being adjusted by varying the number of lamps in circuit. The group of lamps is in series with the battery to be charged, and the combination is connected across the circuit furnishing the current. If the charging source is a 110-120 volt circuit, and the rate required is 6 amperes, twelve 16 c. p. or six 32 c. p. lamps, in parallel, and the group in series with the battery, as shown in the cut, will give the desired charging rate.

Instead of lamps, a rheostat is sometimes used, as shown in cut. The carrying capacity of the rheostat should be slightly in excess of the current required for charging the battery. An ammeter with suitable scale should be inserted in the battery circuit to indicate the current flowing.

varied from a quarter to three aampères, a quarter of an ampère at a time. If, occasionally, a high rate of charge is necessary, the addition of a 100 c.p. lamp to the stock will allow of almost any current up to about six ampères.

Charging from an Alternating Circuit.

For agents who live in towns where the electric supply is an alternating one, and for hotel-keepers and others, an aluminum rectifier should be of considerable use. The rectifier consists of four cells, each containing a lead plate and an aluminum rod, immersed in ammonium phosphate. Owing to the peculiar properties of aluminum, these cells act as an electrical valve, opening to allow the current to flow in one direction, but closing when a reverse current attempts to flow. By this means, an alternating current can be so rectified that it can be used for charging accumulators. The rectifier is inexpensive, and easy to use. The treatment required is somewhat the same as that needed for a primary battery, but the chemicals and aluminum rods only want renewing about once in three months, and the lead plates are practically everlasting. The ammonium phosphate should be dissolved in distilled water, and not in ordinary city water.

Another method is to employ an alternating current motor to drive a small continuous current dynamo. The alternating current wire is connected up to the motor which it drives, the motor in turn driving the dynamo to which it is coupled. The accumulators are then connected up in the usual manner to the wires conveying the current from the driven dynamo. A combined alternating motor and continuous current dynamo can now be bought in a compact and convenient form.

Battery, Storage—An accumulator or secondary battery. See under Battery.

Battery Troubles—See The Battery under Repairs and Adjustments.

Battery, Voltaic—A number of voltaic cells coupled together. The voltaic cell ordinarily consists of plates of two substances, joined by a wire and immersed in a liquid which

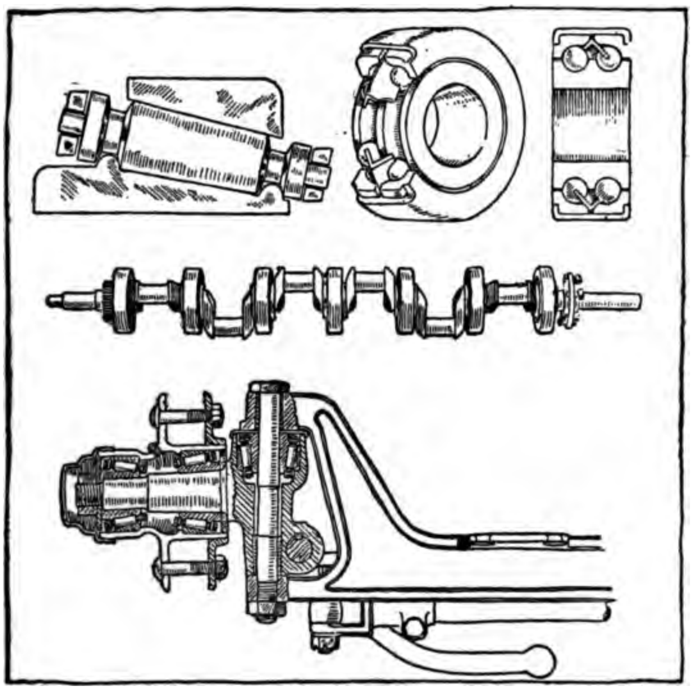
acts chemically upon one plate, usually zinc, at the expense of which the electric current is maintained.

Battery, Wet—An electric battery using liquid acids.

Bauxite—The ore of aluminum. It hardens under the action of heat and is used in grinding.

Bearings—Bearings are of three types—plain, ball and roller bearings, and may be exclusively of one type, or combine any two denominations in one bearing. The functions

NEW TIMKEN BEARING NEW DEPARTURE BALL BEARING



TIMKEN ROLLING BEARING SPINDLE BALL BEARING CRANKSHAFT

of a bearing are to afford a support for some axle or member which revolves, and to accomplish this with as little friction as possible. That portion of the shaft which lies in the bearing is known as the journal, and between this and the bearing a film of lubricant is usually maintained to reduce fric-

tion. The shaft may be made to revolve in the bearing, or the bearing may be made to revolve around the shaft.

Plain bearings consist fundamentally of a female reproduction of the journal on the shaft, which is just sufficiently greater in size than the journal to permit of easy motion and the introduction of lubricant. Usually, however, arrangements are made in designing plain bearings so that different metals shall be opposed for the frictional surfaces, since it is found that less friction is caused between dissimilar metals than between two surfaces of the same composition. With this end in view, castings for bearings generally have the bore "bushed" or lined with the metal which is most suitable for the conditions the bearing has to work under. The bearings employed in the construction of automobiles have to contend with very varied loads and high speeds, so that in order to provide the necessary wearing properties, the bearings are often constructed of phosphor or manganese bronze. These substances are excellent for the purpose, since they give very little friction when opposed to steel, and, further, they possess magnificent wearing properties essential in high speed bearings taking a heavy load. Occasionally, bearings are lined with anti-friction metal, consisting somewhat of the composition of white metal. In this case the bearings are first made in the shape of a cage or framework of durable metal and recessed. The shaft is then placed in position and the recesses filled up with the molten anti-friction metal. When cool, the shaft is removed and the bearing scraped to a fit. Bearings lined in this manner give excellent results, and have the advantage that they can be easily and cheaply renewed.

Ball Bearings.

Ball bearings are those in which a row or rows of hardened steel balls are inserted between the revolving and stationary faces. On account of the infinitesimal frictional contact and the rolling action of the balls themselves, these bearings allow of very high speeds being attained with a minimum of

friction and immunity from overheating. Bearings of this type give good results under heavy loads.

The ball path or races for ball bearings should be **V** or rounded grooves made of hardened steel ground perfectly true.

The starting friction of ball bearings is far less than the best lubricated plain bearings. The friction of ball bearings varies directly with the load, and is independent of speed and temperature.

Though the immense value of ball bearings in a motor-car has long been appreciated, it has been feared that balls would not be particularly happily placed in the journal of a road wheel, because, in spite of the pneumatic tire, heavy shocks are liable to reach the hardened surfaces of the balls and ball-races, and these parts are necessarily brittle rather than tough. This is true, but the difficulty has been met by appropriate design.

Balls would probably never have been placed in such a position were it not that modern machinery and ingenuity has been capable of producing for a very small price a durable combination, consisting of a set of balls with their spacing pieces ready set up in a pair of steel rings or races, so that a completely new ball bearing can be inserted into position and the worn one removed in the course of a few minutes for each wheel at a very cheap rate.

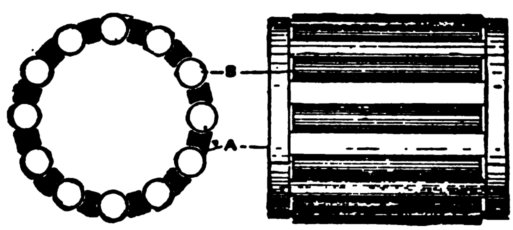
Once any appreciable play or free up and down movement has been started by wear, the ruin of a ball bearing in a road wheel hub is very rapid, because the axle load of at least one-quarter of the weight of the car is free to bounce up and down and deal heavy blows to the parts. This weight may be looked upon as a half-ton hammer, which, though it moves through a distance of only one-sixteenth of an inch, delivers several blows in a few seconds on the balls when the car is driven rapidly over rough roads.

The essential point to observe about a ball bearing is that it shall not be overloaded, either by the utmost road shocks to which it may be submitted or by the straining of the frame

in the case of ball bearings in the gear-box, etc., as such distortion may give rise to very great pressures on the bearings.

Roller Bearings.

Roller bearings embody fundamentally the same principle as ball bearings, and, theoretically, a line contact is obtained in place of a point, as with a ball. The shaft rests within a cage in which rollers are closely spaced, and bears on the rollers, which are free to revolve either freely on their own axes or between the shaft and an outer hard steel casing. The cage is for the purpose of keeping the rollers apart from each other and insuring that they shall always assume a



ROLLER BEARING.

position parallel with the axis of the shaft. The illustration shows end and side views of a roller bearing. A is the cage and B one of the rollers which revolve in the cage.

With roller bearings the same advantages are gained of reduced friction as with ball bearings, but with the further gain that the bearing is not limited to a single point, but can be extended to any required length.

Parallel roller bearings being incapable of adjustment, this difficulty has been met by the use of conical rollers, which may also be so designed as to take up the end thrust which has to be provided for in the case of automobiles. The amount of power that may be saved by the use of roller bearings renders them extremely valuable in auto construction, and they have given excellent results in rear axles and transmission.

Spigot Bearing.

The spigot bearing takes its name from a spigot, generally of wood in the form of a plug in a hole, the earliest type of tap or cock for vessels and still used in some parts. Such a tap is termed a spigot or faucet. In motor practice, where it is advisable to make one shaft take a bearing in another shaft, the axes of the shaft being coincident, a bearing is used called a spigot bearing, one end of one shaft being reduced in diameter and made to fit in the bored out end of the outer shaft. It is practically only used in the shafts of gear boxes in cases where a direct drive is required on one of the speeds, and in our description of gears examples of it will be seen. See Gear. A spigot bearing is sometimes used in clutches between the engine crankshaft and the male member of the clutch. See Clutch.

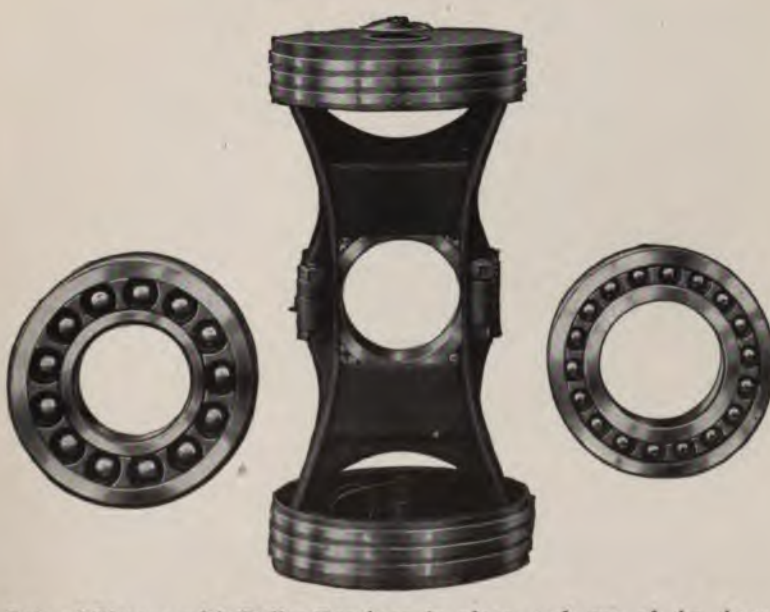
Other Types of Bearing.

Bearings are also named from the function they perform —for example thrust bearings, collar bearings, cone bearings. These terms, however, denote the combination of the male and female portions.

A collar bearing consists of a journal bounded by two collars or parallel concentric projecting rings turned solid with or in some way attached to the body of the shaft, working in a bearing which just fits between the collars so as to permit of rotary but not of lateral movement. Collar bearings are largely used in motor car construction.

Thrust bearings, as the name implies, are utilized for taking the thrust or end pressure off a shaft. There are many forms. One common variety consists of a series of collars turned on the shaft, which fit into similar recesses in the female portion, which is split in two halves to permit of assembling the bearing. The multiplicity of collars so divides the load on each recess of the bearing that it is not excessive on any one, thus obviating excessive wear or friction. In many high-class cars, thrust bearings are made combinations of plain and ball bearings, the balls being interposed between

Hess-Bright Bearings.



Pair of Pistons with Roller Bearings in place, and two of the three 5″ radial Ball Bearings used on motor shaft, New Model Holsman.

collars and the ends of the bearing. Thrust bearings of this type give exceedingly good results, and set up very little friction. Where a bearing takes a constant heavy load the collars are sometimes made the cages of roller bearings.

A compound bearing is one which takes a thrust in the direction of its axis as well as a load across it.

N. B.—No shaft should be free enough in its bearing to be appreciably loose in it. If there is play, rebush the bearing when you are next at home and at leisure. If engine bearings are loose, drive slowly, avoid advancing the ignition lever unduly. The most important bearings to keep tight are those which are subject to reciprocating action; for example, those on the connecting-rod. For continuously running plain bearings the load should not exceed 300 lbs. per sq. in.

Bearings, Hot—Provided that the bearing has been properly designed, and that the bearing surface is therefore ample, the most frequent cause of hot bearings is grit, which may be carried into the bearing with the oil or get in by some other means. Immediately a heated bearing is discovered, the bearing surfaces should be flooded with oil and the journal kept turning slowly in the bearing until it has cooled down sufficiently to admit of being dismantled. The bushings should then be taken out and examined. If no scoring is visible either on them or the journal, they should be cleaned and replaced.

If either the bushings or the journal are scored, and the scores have sharp edges, the sharpness must be removed with a scraper or fine file, then the bushings and journal cleaned carefully and replaced. Never pour water on a blazing hot bearing; it will probably cause the cap or other casting to crack, owing to sudden and unequal contraction.

Hot bearings are frequently caused by the bushings being too tightly screwed up or to their being badly fitted. The remedy in either case is obvious. Bearings are chiefly liable to get hot with a new car or engine, so that extra care must be taken to lubricate thoroughly until the bearings have become well bedded.

Bearings Seized—See Miscellaneous Roadside Repairs.

Bedplate—The metal foundation-plate of an engine, etc.

Beginner—The novice who begins the study of the automobile and is desirous of obtaining a practical and thorough knowledge of the subject, so that he may operate, adjust or repair a machine understandingly, may at first find himself in a seeming maze of technicalities. These, however, will soon straighten themselves out and the beginner who pursues the simple, systematic course of reading indicated below will speedily absorb the right kind of knowledge of the subject and find himself growing more and more familiar with the mechanical features of the somewhat complex machine as well as with the more general problems that arise in automobiling. Naturally, the first thing to do is to get a general idea of what a motor car is, the most important parts of which it is composed and the properties and functions of each part. The beginner will save time by adopting the following plan in using this work of instruction and reference, after acquainting himself, if he wishes, with the history of the automobile:

Motor Cars—He should first turn to this heading in its alphabetical place in the cyclopedia and he will there be able to follow the general design. He will then see that the engine, in which the power is generated, is usually in front. That it revolves a shaft known as the crank shaft. That this shaft is connected with a flywheel, and that a piece of mechanism called a clutch forms a connection (which can be broken at the will of the driver) between the flywheel and another shaft called the clutch shaft, which in turn is connected, by universal joint or otherwise, with the primary gear shaft. This latter shaft enters the change speed gear box. From the gear box the power is transmitted in either of two ways: by a countershaft, sprocket wheels and chains to chain rings on the rear road wheels, or by a central shaft (arbor, propeller, or cardan shaft) to a bevel wheel in the rear live axle through which the road wheels are revolved.

The generation of the power is the next point of im-

portance. The descriptive matter under the following headings should be studied in order:

Internal Combustion Engine; Carbureter—The explosive mixture is formed in the carbureter, and is sucked into the combustion chamber of the engine by the movement of the piston, where at the proper time it is ignited, and, expanding, causes the pressure on the piston head which revolves the crank shaft. The firing of the charge is dealt with under the headings which follow.

Electricity; Ignition; Battery; Coil; Contact Maker; Contact Breaker; Timing—Under Electricity is briefly described that form of energy which produces the firing spark. The different systems of ignition and their methods of working are described under Ignition. Under the other headings are more fully described the vital parts of the complete system and the method of timing the spark and the opening and shutting of the valves.

Governor—This is a device for controlling the speed of the engine and so varying the power. The exact modus operandi is described under Governing.

Circulation; Pump; Air Cooling; Water Cooling; Radiator—Under these headings are described the methods adopted for cooling the engine.

The transmission system generally is dealt with under a number of headings, which should be studied in the order given below:

Transmission; Clutch; Gear or Gearing; Change Speed Gear; Shafts; Wheels; Chains; Axles—Under Transmission the system is described in general terms, while the various parts are dealt with under the other headings.

The beginner will now thoroughly understand the general principles of the motor car, and may with advantage read through the cyclopedia from cover to cover, including those portions already studied. Before finally selecting a car the intending purchaser should carefully peruse the advice contained under Choice of Car.

Bells—Foot bells were formerly much used as a means of signaling the approach of automobiles, and for electrical cars they are still used, but the horn is now generally adopted.

Belt—A continuous band or strap of flexible material used for transmitting power from one pulley wheel to another. At one period belts were largely used in automobiles for transmitting the power to the back wheels. They are now only used for driving a fan in connection with the cooling system.

Belts for motor cycles used to be formed of twisted rawhide, adjustment being made by twisting or untwisting until the proper tension was obtained. The V-shaped belt has now come into almost universal use. It wedges in the pulleys and thus gives a much better grip than the round belt. The flat belt which at one period was popular is now only used for some high-powered racers.

Belt-Dressing—A compound for increasing the adhesion of a belt or for preserving a belt.

Belt-Drive—The transmission of motive power from the engine to the countershaft or jackshaft by means of one or more belts. Belt driving for automobiles has fallen into disfavor, as, despite the smoothness of transmission, there are too many drawbacks in the way of slipping, loss of power, etc.

For motorcycles belt driving is most in vogue, and seems very suitable. It takes away the harsh running associated with the chain drive and lessens the strain on the engine when starting. Belts give trouble in wet and muddy weather, unless well protected and kept in supple condition by treatment with castor oil.

Belt, Spring Fan—See under Circulation.

Benzene—A coal tar product (C_6H_6), synonymous with benzol. Some confusion is caused by the similarity of this word with benzine, which is a petroleum product.

Benzine—One of the heavier products of distilled petroleum,

and closely allied to the naphtha group. It is heavier than gasolene, but may be used in an emergency.

Benzol, Benzolin—Same as Benzene.

Bessemer Process—The method invented by Bessemer of decarburizing cast iron. By this process steel can be made much more cheaply than formerly. It consists fundamentally of blowing a current of air through the iron while molten.

Bevel Gear—See Gear and Gearing.

Bevel Pinion—See Wheels.

Bevel Wheel—See Wheels.

Bicycle—A modern modification of the two-wheeled velocipede, propelled by the pedal action of the rider.

Bicycle, Motor—A bicycle propelled by a gasolene or other motor. See Motorcycle.

Big End—A term used to describe that end of the connecting rod which is attached to the crank pin. The piston end of same is often called the little end.

Binding-post—In an electrical apparatus a small post having a hole or groove into which a wire is inserted or through which it passes and is held by a screw. A looseness at the binding-posts will often interrupt a current and cause trouble which is easily removed.

Binding Screw—See Screws.

Bit—A loose term applied to small tools, such as drills, center bits, flat and twist drills, and other small tools suitable to be held and operated in a hand brace or hand drilling machine. See Tools.

Blacklead—See Graphite.

Blade Contact, Truing Up—See under Ignition.

Blank—A piece of metal prepared to be formed into some finished object by a further operation.

Bleeder—The "feeds" of certain mechanical oiling systems for automobile use are fitted with devices called "bleeders." By turning the thumb cover of any feed to one side and open-

ing a valve, the oil that would be delivered through that feed to the bearing is allowed to pass out at the tip, through a hole directly under it, and back into the tank in drops.

Block—A mechanical contrivance consisting of one or more grooved pulleys mounted in a casing or shell and used to transmit power or change the direction of motion by means of a rope or chain.

Block Chain—A form of sprocket driving chain made of a series of blocks shaped to fit the sprocket and joined by links.

Blow-back—This term is used to describe a blow-back of gas, whether ignited or not, through the inlet valve into the carbureter, which causes a loud popping. Its causes and the remedies therefor are fully described under Blow-back in Repairs and Adjustments.

Blower—A device for the production of a current of air.

Blow-out—The breaking of a pneumatic tire through both casing and inner tube.

Blowhole—An air-hole in a casting, causing a defect in the metal.

Blow Lamp—See Tools.

Blow-Off Cock—See Cocks.

Blow-off Valve—See Valves.

Blowpipe—An instrument by which a current of air or gas is driven through the flame of a lamp, candle, or gas-jet, to direct the flame upon a substance in order to fuse it. It is used for soldering, brazing, etc.

Boat, Motor—See Motorboat.

Body—The different types of bodies used on motor vehicles are defined by different names. Thus we have the Berline, brougham, convertible, detachable, doctor's cab, landaulet, limousine, racing, Roi des Belges, tulip, and two-seater.

Berline—This is a body in the form of a kind of large double brougham, and can be compared most nearly with a double limousine; that is to say, a limousine body having more than

two seats in the back part of the body. It takes its name from a type of carriage which was used in France for traveling and sleeping purposes.

Brougham—A brougham body is a closed-in body with windows in front and side doors, but without any extension of the roof over the driver's seat.

Convertible—A convertible body is one which can be used in a variety of ways, either as a closed or open carriage, or in some cases can be partly closed and partly open. Other forms of convertible bodies are those in which the body normally is used as a two-seater but there is a concealed seat behind the back portion of the body which can be raised so as to add more seating accommodation.

Detachable—Detachable bodies are now often fitted. They allow of several different types of bodies being used on the same chassis. An example of a convenient arrangement for detachable bodies is a patented sliding body, the body work having legs which can be turned down, with casters at their end to allow of the body being slid off backward from the chassis and another body substituted.

Doctor's Cab—One of the late types of bodies is the doctor's cab body, specially adapted for doctors' use. The back portion takes the form of a hansom cab body, the entrance being from the front and at the left-hand side of the front, the driver's seat occupying a position on the right and in front of the cab body. It allows of a short wheel base and easy turning in traffic, and is, of course, only suitable for two passengers, excluding the driver. Other styles of doctors' cabs are those in which the car is practically a two-seated brougham, but having no front seat, the driving being done from inside the brougham, with the steering wheel and control mechanism inclosed. There are side doors and a large glass front.

Landaulet—A landaulet is similar to a limousine, but the back is made with a cover which can be let down just the same as the back half of a landau, thus leaving the back of

the car open. The front roof generally extends over the driver and remains in position when the landaulet back is let down.

Limousine—The limousine has a closed-in body with glass sides and front and side doors with glass windows, and sometimes also closed back windows. The roof extends over the driver's seat, is supported by steel columns, and generally a glass wind screen is fitted between these supporting columns.

Racing—A racing body is generally made as light and as low as possible, and usually consists of two seats with short backs set down on a cross framing on the chassis frame. The idea of the racing body is to reduce the weight to a minimum, to arrange the seats so that they give reasonable support at the sides and back, and to get them as low down as possible so as to decrease the windage.

Roi des Belges—A European style of body of the four, five, and six-seated variety, with side-entrance in which the panels are bellied out and turned over at the top, the upholstery being carried over in a roll round the top of the back and sides, with the front seats similarly arranged and upholstered.

Tulip—Very similar to the Roi des Belges, the curve of the back and sides of the seats being more pronounced.

The Two-Seater—A type of body including only two seats. See Carriage Work.

Body Types—See Carriage Work.

Boiled Linseed Oil—See under Oil.

Boiler—That part of a steam car in which steam is generated. Three types of boilers are fitted to steam motor cars—fire tube, water tube, and flash boilers. See Motor Car.

Bolts and Nuts—The bolt is a length of metal of circular section, which has a head formed at one end and has the other screwed either to receive a nut or to enter a tapped hole; in the latter case it is more properly termed a set screw. The nut is a block of metal with a central hole screwed internally to take the externally screwed end of the bolt, and very generally corresponds with the head, between which and the nut the two parts to be fixed together are held.

Bolts.

The most usual types of bolts are as follows:

Common Hexagon bolt—This is used to bolt two or more pieces of material together.

Cheese Head bolt—This has a flat circular head with slightly beveled top edge.

Snug bolt—A bolt which has a small projection under the head to prevent the bolt from turning.

Round Head bolt—A bolt with semi-spherical head.

Fang bolt—A bolt having no head, the plain end being turned over on itself so that both ends of the bolt point in

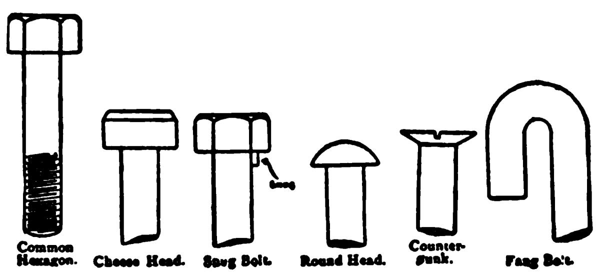


Fig. 1.—Bolts.

the same direction. The turned over end is sometimes under-cut so as to form a barb like a fish hook. This type of bolt is used when it can be cast in position with the metal it has to fix, the fang end then preventing it being withdrawn.

Countersunk bolts for iron—These are of two types, one with a plain flat circular head like a cheese head with a saw-cut across for a screw-driver, the other having a circular head tapered towards the point at an angle of 120° to the axis of the bolt. The heads of these bolts are sunk in a recess to enable the bolt to lie flush with the surface of the material.

Countersunk bolt for wood—This has a tapered head similar to the last, but larger, to prevent the bolt pulling through the softer material.

Square headed bolt—A bolt having a plain square head.

Nuts.

The most usual forms of nut are as follows:

Common Hexagon nut—This has six sides on which the spanner grips, as used in coachbuilding.

Milled nut—A nut having a circular edge, which is roughed or serrated in the same manner as a gold or silver coin. It affords a firm hold for the fingers for screwing or unscrewing. Terminal nuts usually have milled edges. Screws, caps, and other small parts are often provided with such edges to obviate the use of tools. The process of forming the edge is technically known as milling or knurling.

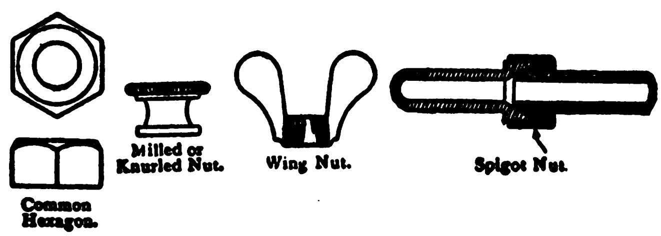


Fig. 2.—Nuts.

Fly nut, wing nut, thumb nut or finger nut—An ordinary nut provided with projections or wings to give a surface for the thumb and fingers to grip.

Spigot nut—A nut used to connect two pieces of tubing end to end, usually called a union nut.

Back nut—A nut used at the back of the screwed sockets by which the two screwed ends of metal pipes are joined together. Its use is to tighten the threads of the socket onto the threads of the pipe.

Locking Devices.

When parts screwed together are placed in positions where they have to undergo vibration, locking devices are provided to prevent them slacking back after being tightened up.

Common lock nut—The commonest form of lock is an ordinary thin nut on the bolt end on the top of the standard nut, the two nuts keeping one another locked in position. In using

this kind of lock it is necessary to hold the bottom nut while the lock nut is screwed down tightly upon it.

Castle nut and split pin—A nut having transverse slots cut across its top face to receive a split pin after the nut has been screwed up tight and the bolt drilled through in line with one of the slots. This absolutely prevents the nut from shifting.

Helicoid nut—This nut is in reality a helical spring internally threaded, which, when screwed down tight, keeps up a constant pressure against the under side of the thread, so that it cannot work loose.

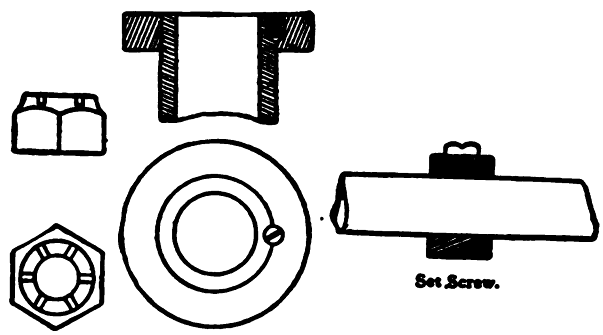


Fig. 3.—Locking Devices.

Spring washer—In this case the washer takes the form of a helix of flat spring steel around the bolt, which keeps the nut always tight up against the thread, and is inserted between the work to be held and the bottom of the nut holding it.

Set screw—A bolt threaded up to the head, used for setting collars in position upon a shaft.

Grub screw—A small screw without a head, provided with a cross cut for screw driver. It is screwed into the thread "half and half" parallel with the axis of the bolt in order to prevent the screwed piece from loosening. Sometimes called a spindle screw.

Bonnet—The complete case or cover of a motor engine, usually of sheet steel and often called a hood. Also applied to the pan under a power-plant.

Boot—A protective casing for universal joints; a receptacle for baggage behind a car.

Bore—The term used to denote the inside diameter of the cylinder. It is used in conjunction with the term stroke, which denotes the distance over which the piston travels; thus half the stroke would be the throw of the crank shaft. See Internal Combustion Engine. From the bore and stroke, together with the speed of the engine and the compression pressure, a formula is obtained from which the horse-power of the engine can be determined.

Boss—The enlarged part of a shaft on which a wheel is to be keyed, or any enlarged part of the diameter, as the end of a separate piece in a line of shafts connected by couplings.

Bowden Wire—A device for transmitting pulling motion from one point to another. It is useful for many purposes, as it can be led over or round any obstacle. Briefly, it consists of a helical spring wound closely so as to form a continuous tube. This tube is anchored at each end. Through the bore of this tube runs a stranded steel cable, one end of which is attached to the hand lever. The other end of the cable is attached to the member to be moved. It can be used for control levers, brakes and in almost any position where a reciprocating motion is required, but where rigid connections would be difficult to get. The cable is returned to position by means of a spring.

Box—See Gear Box, Steering Box, etc.

Box Spanner—See Tools.

Box Stuffing—A close box cast round the hole through which a piston rod, etc., passes to contain the packing that secures the joint.

Boyle's Law—The law of physics that at any given temperature the volume of a given mass of gas varies inversely as the pressure which it bears. Discovered by Robert Boyle about 1662.

Brace—A curved instrument of iron or wood for holding and turning boring-tools, etc.; a prop or support.

Bracket—A term applied to a small part fixed to a big part to hold some unit of a mechanical construction. Brackets are used to carry bearings for such parts as the rocking levers of brakes and gear-operating mechanism. Brackets are sometimes used to attach such parts as magnetos, pumps, carbureters, etc., to the heavy parts of the engine.

Brake Band—That part of a brake which is contracted around a drum to apply the necessary friction. It is generally of spring steel and lined with leather, or, in more recent practice, metal segments. See Brakes.

Brake, Band—See under Brakes.

Brake-block—A block or piece that holds the brake-shoe.

Brake Block—One of the blocks of metal drawn into close contact with the outside of a drum to apply braking friction, as in the modern types of countershaft brakes; or one of the similar blocks of metal which are forced outwardly into close contact with the inside of a drum, for the same purpose, as in the case of internally expanding brakes. See Brakes.

Brake Drum—The drum or pulley around which the brake band is contracted or against which the brake shoe or block is drawn, or inside which the brake shoes are expanded. See Brakes.

Brake Lever—Generally the side hand lever which in most cases is used to apply the brakes on, or in, the drums of the rear wheels.

Brake Pedal—The foot lever which is generally used to operate the brake on the countershaft or gear shaft. See Brakes.

Brake Pedal—See Pedals.

Brake Pulley—Same as Brake Drum.

Brake Rod—The rod which couples the lever operating the brake to the brake mechanism proper.

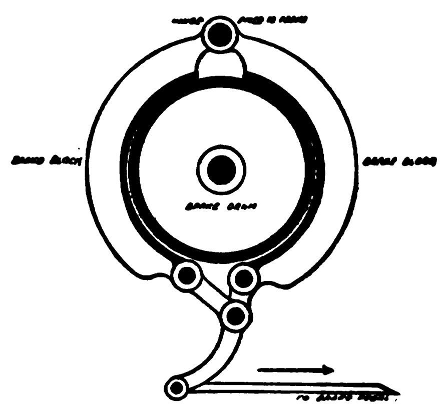
Brakes—The term brake is applied to any mechanical device for retarding or checking the motion of a moving part by friction. In the most approved practice brakes are made

double-acting, and many are fitted with water-cooling arrangements.

The principal types are as follows:

Band Brake—Usually applied to the jackshaft, or countershaft, of an automobile or to drums fixed inside the driving wheels. By a system of levers the circumference of a thin and pliable steel band lined with leather, wood, copper, or some substance to increase the grip, is contracted round a hollow-flanged pulley, thus gripping the surface of the pulley and retarding its motion.

The defect found in the earlier types of band brakes was



Action of a Band Brake.

that, though acting well with the car moving, or tending to move, in a forward direction, yet if the tendency were reversed the brake was useless, owing to the tension in the brake strap being released. In order to overcome this defect what are known as double-acting brakes are now fitted to cars. These, in place of the band, have a pair of metal clips arranged about the brake drum, hinged together at one end. The motion of the brake pedal causes mechanism, independent of the remainder of the braking mechanism, to close the two halves inward and grip the brake drum. By this arrangement the braking action is rendered equally effective in either direction. For wheel brakes expanding band brakes are in use.

These act internally on drums firmly fixed to the driving wheels, and are more reliable than the ordinary pattern. They are also cased in away from the dirt, which proves a great boon by preventing clogging. These brakes are usually double acting, and in nearly every case the friction surfaces which bear on each other are of metal.

Compensating Brakes—In applying brakes to the rear wheels of motor cars it is necessary to remember that each wheel should be braked equally, otherwise the tendency would be to turn the car about a center occupied, or approximately occupied, by the wheel which is under the greatest retarding effect. For this reason it is necessary that all brakes applied to these wheels should be compensated—that is, the force tending to pull on the brakes should be so applied that it acts equally on each wheel. This is sometimes accomplished by means of a twisted cable, one end of which is attached to one brake and one end to the other. The cable runs through a hollow shaft on which the brake lever is fitted, and as the lever pulls on the brakes the cable can slide through to adjust itself to the pressure, so that there is always the same pressure applied at either end of the cable, and the brakes are, therefore, always applied with the same pressure.

Where the brake is applied around the differential gear, or on any of the transmission shafts, the differential gear itself forms the compensating device. But in all these cases, of course, the brake's effect has to take place through the gears, which puts a strain on them not present where brakes are applied on the wheels. In the latter case the compensating arrangement sometimes takes the form of a floating line, the ends of which are coupled to the brakes, and the power applied at the middle. This forms the most effective compensating arrangement for this type of brake.

Magnetic Brakes—In one case at least the retarding effect is set up by opposing electro-magnets to the face of a revolving disk. See Auto-Mixte under Change Speed Gear.

Tire Brake—A shoe or block of some material, which is caused to press against the tires of the rear wheels by a

lever. Its excessive application causes undue wear and it is now obsolete.

Effects of Adhesion.

The speed of stopping by means of the brake depends on the extreme limit of adhesion of the wheels to the road. On a given road surface the adhesion of the back wheels is proportional to the weight on the back wheels. The momentum of a car being proportional to its mass (which for present purposes may be taken as measured by its weight), it is clear that when more passengers enter a car and add to its load they do not alter the limiting rapidity of stop on the level, provided their weight is all borne by the back wheels. Tonneau passengers may be considered to be entirely borne by the back wheels. Those on the front seats are about half on the back and half on the front, and therefore only one-half their weight is useful in securing adhesion for braking or driving purposes. In illustration of this it is often found that powerful cars with a heavy engine in front are far easier to drive, easier to start, easier to stop and skid less up hill with the full complement of passengers in the back seats. For the same reason such a car is easier to handle when fitted with non-skids.

The coefficient of friction between rubber and road is very high (0.6), indeed much higher than the coefficient between an iron tire and the road, and much higher still than the friction between an iron tire and an iron rail. Hence the automobilist is safer than on a railroad if only he remembers that this valuable coefficient falls off the moment the wheel is locked strongly enough for it actually to begin to slide. To avoid sliding of the road wheels, therefore, the pull on the brake handle (which can easily be made as small as the designer pleases) should not be made so small that the driver can with the greatest ease lock the brake. It is no test of a brake being good to apply it on a stationary car and then start pushing the car. Many a salesman is proud to claim that his brake is perfect because it locks the wheels at once. He is in error and misapprehends the functions of a brake.

The Art of Braking.

Part of the art of driving and properly applying the brakes to an automobile consists, in addition to never locking the wheels, (1) in never obtaining a retardation effect greater than about 10 feet per second, and (2) in taking off the brake just before the actual stop is effected.

Good driving in traffic is shown by making the minimum use of the brakes. The nervous strain on the passenger amounts to intense annoyance when the car is constantly driven so that the least alteration of direction or of pace on the part of any vehicle ahead, or at the side, results in the violent application of the brake. If it is imperative that a distance in town should be covered with the utmost possible speed, a few seconds per mile may be gained by such driving, but the wear and tear of the car is disproportionately great, particularly if the foot brake, or the brake which operates on the countershaft, is the one selected by the driver for this violent use.

Brake Adjustment.

It is essential that the brake band should, when not applied, be absolutely clear of the drum when the working position of the brake is adjusted to the fiercest practicable point; unless the brake drum is quite free it is clearly waste of time and material to employ roller bearings and other friction minimizing devices at great expense throughout a car. Many band brakes of the simplest kind depend solely on the elasticity of a steel band to spring off the drum. These brakes are inclined to rub a little somewhere, and when dirty are liable if badly designed to rub a great deal everywhere—a drawback which is borne with in cheap cars. Brakes in which the rubbing pieces are made of solid blocks, however, are usually provided with hold-off springs, a refinement well worth having. Another modern car improvement is to so design the brakes that they are totally inclosed (as in some kinds of internally expanding brakes), so that grit and mud are excluded. In such a case it is as well to see that the wear-

ing pieces are nevertheless easily accessible and easily adjustable.

The adjustment for wear of brake blocks, and stretch of the links which apply the brake, should be thoroughly easy of access and easy of operation, otherwise the temptation to neglect adjustment when a hurried start happens to be required is irresistible, and accidents may result. One link at least in the brake arrangement should be capable of being easily shortened by a right and left-hand screw arrangement or turnbuckle.

A careful driver examines the brakes of a car before starting or tests them within a few yards of leaving the garage to see if they are in good order and adjusted. In doing this before his passengers are aboard he very often forgets that the hand brake on which he relies for an emergency is in almost a majority of cars liable to be more or less put out of adjustment by the load in the back part of the car. This point should therefore be remembered and the hand brake should be tested after the passengers enter the car.

Typical Modern Brakes.

The braking system of the Locomobile cars is typical of modern American construction. The brakes are three in number—a foot brake, located on the countershaft, and two internal expansion brakes on the rear wheels. All brakes are of the metal-to-metal variety, which is claimed to be the best possible braking combination with the least wear. The brakes are also double-acting and the frictional surfaces are large. The total braking surface on the 20 H.P. car is 220 square inches, and on the 40 H. P. car it is 320 square inches.

The foot brake is extremely powerful. It is engaged by pressing a pedal with the right foot, the action of which does not disengage the clutch—a convenience which is of importance. It is adjusted by two turnbuckles, located at the front, and after the brake has been taken up, the band can be adjusted around the entire circumference so that there is no

binding or dragging. The halves of the brake are hinged at the rear.

The internal expansion brakes on the rear wheels are completely inclosed and lubricated by non-fluid oil.

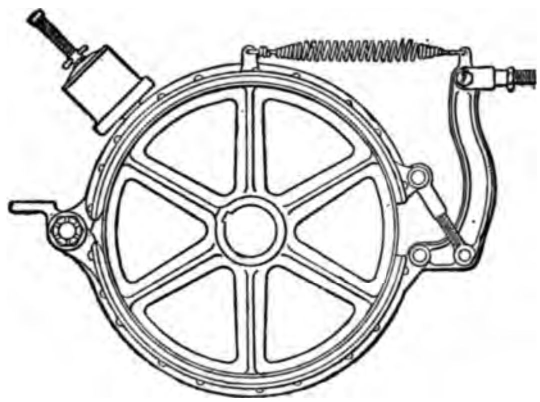


Diagram of Running Brake—Locomobile.

The brake-shoes are hinged at the top and when the hand-lever is pulled backward, simple and suitable mechanism causes the brake-shoes to be expanded against the circum-

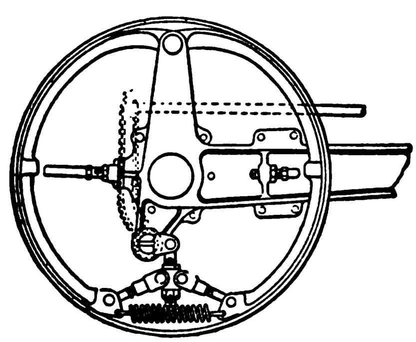


Diagram of Emergency Brake—Locomobile.

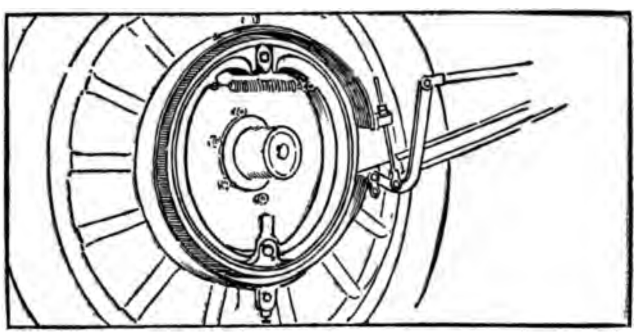
ference of the drum; when the hand lever is released, springs draw the bands away from the circumference of the drum.

The emergency brakes can be adjusted by shortening the wire cables which are connected to the hand-lever, and any

further adjustment which may be needed after a long period of time may be made by removing the wheels and lengthening two turnbuckles at the bottom of each brake.

It is the usual custom in up-to-date cars to couple the countershaft brake in the case of a chain-driven car, or the gear shaft brake in the case of a gear-driven car, to a pedal on the footboard, while the road brakes are coupled to a side hand lever.

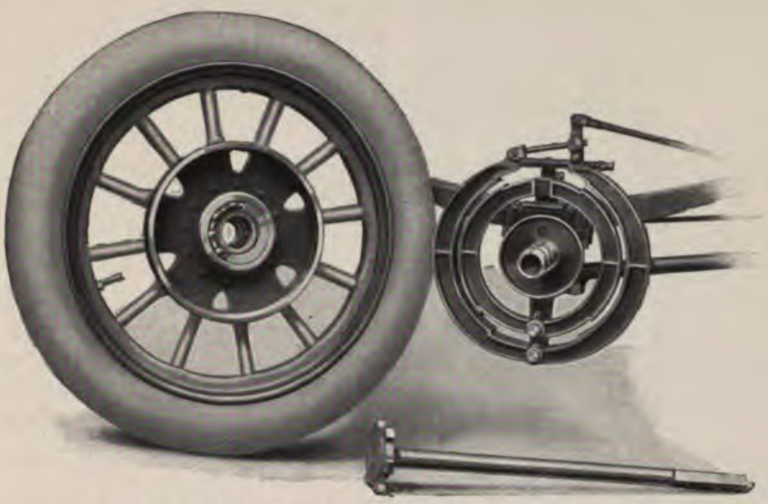
The most recent type of compensating arrangement for back brakes is that in which a drawbar is interposed in the operating mechanism. This drawbar is pivoted at its center on the pull rod operated by the brake lever. Its two ends



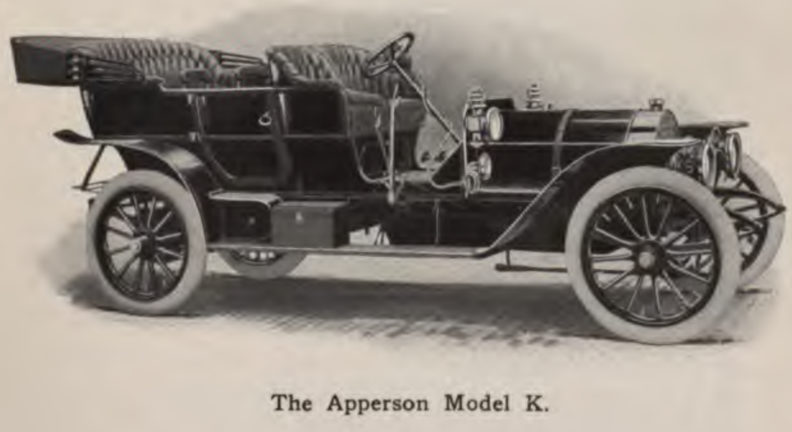
Double Internal and External Hub Brake.

are connected, one with the brake lever on one hub and the other with the brake lever on the other hub. The pull takes place from the center, and the pressure applied to the two brake levers is consequently equalized. In some cases these draw bars are short, but in the most modern practice they are long, generally extending the full width of the chassis frame.

Another method sometimes adopted is to utilize the differential gear. Each brake lever on the hub brakes is attached to a segment of a bevel crown wheel, while the pull rod from the hand lever is attached to an arm carrying a bevel pinion which gears with the segments of the crown wheels; this being pulled over equalizes the pressure on both brake levers just in the same way that the same arrangement equalizes the driv-



External and Internal Metal-to-Metal Rear Hub Brakes—
The Car De Luxe.



The Apperson Model K.

ing pressure on the road wheels in the case of a differential gear.

Sometimes the engine is so arranged as regards its valve mechanism as to be capable of being used as a brake. In such cases the valve cams are duplicated on the camshaft, and, by sliding the shaft along, a cam, operating in a different way, can be applied to the valve plungers. Generally it is applied so as to keep the exhaust valve closed, or partially closed, when the engine acts as a powerful pump, compressing the air in the cylinders. The clutch is kept in, and the forward movement of the car is checked by the air cushion formed in each cylinder. This proves an efficient brake—very elastic in operation, and without the disadvantages of wear and heating which tend to put other brakes out of proper adjustment and cause them to become inefficient on long grades.

Brake-shoe—The part of a brake which comes in contact with the surface on which the brake acts.

Brake Spring—The spring which keeps the shoes or the bands of the brake away from the drum or pulley. Sometimes known as the "take-off spring."

Brass—A yellow malleable metal alloy, composed approximately of two parts of copper to one part of zinc. This metal is used to a great extent for making fittings and accessories, as it is easily worked, and takes a high polish. Also a term sometimes applied to the fixed portion of a plain bearing in which a shaft runs. See Bearings; Bushing.

Brass Lamps, Cleaning—See under Cleaning.

Brass Wire—See Wire.

Brazing—The perfect union of two metallic bodies by means of brass. Wrought iron or steel members may be joined together by preparing the faces of the joint by filing up until they make a good contact with each other. In cases where one circular piece is to be fixed inside another piece, each is made a loose fit in order to allow the brass to run between the faces. The parts to be joined are subjected to heat by

means of a blowpipe or fire. When red hot, a flux of borax or a mixture of borax and boracic acid is applied to enable the brass to flow freely. After sufficient flux has been applied, spelter, or brass broken up into small grains, is added, and melting with the heat, completes the joint.

Brass, gunmetal, iron and steel can all be united by brazing, which is analogous to soldering. The pieces of gunmetal which it is desired to braze together must be thoroughly cleaned, finishing with dilute acid, all traces of which should, however, be removed. Then take some spelter or other brazing metal, reduced to the form of filings or granulated, mixed with powdered borax, and introduce around, and as far as possible, into the joint. Next expose the whole joint over a clear fire, or to a blowpipe flame until the spelter has melted and formed a good joint. If necessary, the parts may be held together during the operation by some form of clamp—which should be kept hot—or they may be bound together with iron wire, so arranged as to be clear of the joint.

It is practically useless to braze such a thing as a pipe into a cast iron cylinder as the cast iron will crack away close to the brazing.

Breakdown—Breakdowns must occur in all machinery, and therefore its accessibility is of the utmost importance to avoid a great deal of useless dismantling for a small adjustment. Serious breakdowns practically never occur on a well-cared-for car. Quasi-serious breakdowns are due to forgetfulness of the proper tools and stores. Perfect upkeep practically disposes of complicated causes of stoppage. On a well-kept car troubles only occur one at a time, and a little logical testing localizes it so that when it is removed (in a few minutes) you are sure of a start without further hunting.

A serious breakdown might be described as one which takes an afternoon to repair. Under this definition it will be seen that many an apparently serious breakdown occurs simply from the owner failing to satisfy himself on a simple matter before starting, say the presence of a spare plug, or of the state of his contact breaker, etc. The number of these details

being large, the best way to make sure of getting to the end of a journey is to overhaul the car before starting. This overhauling will take one or two hours of careful uninterrupted work, not hard work, but attentive work. Any mechanic is fairly entitled to take this length of time, and if he be a trustworthy man he should not be urged or hurried.

Breakdown, Complete—See under Miscellaneous Roadside Repairs.

Breaking of Water Pipes—See under Circulation.

Break Spark—See Ignition.

Breaker Strips—A term applied to strips of canvas laid in between the tread or wearing surface and the body or carcass of a tire casing. When a tire wears down to the breaker-strips, it is usually time to have it re-treaded. Mud or sand works in, through cuts, between these breaker-strips and the rubber tread and separates them. Then you have sand blisters or mud-boils—or the tread breaks loose in strips.

In a recently patented construction, the breaker strips used are made from what the makers call "rivet-fabric." It is specially woven and looks like a checkerboard with ¼-inch squares. The black squares are holes. The heat and pressure of curing forces the rubber through from both sides and unites or rivets together with the rubber of the tread with hundreds of rubber rivets, ¼-inch apart. The whole tire is as solid as though no breaker-strips were there, and the designers claim that no mud-boils can form, and that the tread cannot be loosened.

Breech Piece—The detachable end of the cylinder or other like piece; a member which closes the end of a cylindered chamber.

Bridge Piece—See Dog.

Bridle—A link, flange, loop or other attachment for limiting the movement of any part of a machine; the loop connecting a slide-valve to the valve-rod.

Broken Cylinder—See under Cylinder.

Bronze—A reddish brown alloy of copper and tin, sometimes containing small proportions of other substances, such as phosphorus. Phosphor bronze can be rendered as tough as wrought iron, or as durable as steel, and is used principally for bearings.

Brush—A flexible piece of brass, copper, or carbon used for collecting or distributing the electric current from the contact maker. See Contact Maker; Dynamo; Ignition.

Brush Holder—The insulated holder which holds the brush which collects the current. In case of a dynamo it is movable around the axis on which the commutator moves for adjustment purposes, and, in the case of a wipe contact maker, for timing purposes.

Brushes for Cleaning Cars—See under Cleaning.

Buckboard—A four-wheeled carriage in which a long elastic board or frame is used in place of body and springs.

Bucket—A folding bucket is a desirable part of every kit. The lack of a bucket in case of a leaky pipe, a defective pump, etc., may prove an annoying cause of delay.

Buckle—The indenture or distortion of a tube by overstraining. A deviation of the rim of a wheel from the center line of the same.

Buckling—A term used to describe the deformation which takes place in the plates of a battery when improperly charged or discharged; also the deformation of wheels and other parts.

Buffer—Any apparatus for deadening concussion between a moving body and one against which it strikes, as a rubber cushion in the spring of a motor car.

Buffing—The act of polishing with a buff-wheel or buff-stick.

Buggy—A light four-wheeled vehicle with one seat and with or without a top. The motor-buggy is a high-wheeled vehicle equipped with a motor and belt or chain drive.

Buggyaut—A trade name for a high-wheel motor car

now manufactured by the pioneer Chas. E. Duryea. See illustrations, etc., under Motor Car.

Burner—A device for heating the boilers of steam-cars, by means of vaporized gasolene or kerosene.

Burner, Acetylene—A burner, made of lava, etc., for use in acetylene gas lamps.

Burner, Bunsen—A gas burner named after the German inventor, arranged in such a way that the gas, just previous to burning, is largely diluted with air and thus produces a non-luminous and very hot flame. Formerly used in the ignition tubes of automobiles and still used in heating the boilers of steam-cars.

Burner, Oil Furnace—Used on a steam car to mix the oil vapor and air in proper proportion to insure complete combustion and supply the necessary heat to the boiler.

Burners are made in a variety of designs, but may be divided into two principal types: (1) Those in which the mixture is sprayed evenly on the bottom of the boiler by being passed through an immense number of fine holes, the number being proportional to the size of the boiler. (2) Those in which the mixture passes through one hole and is projected by a nozzle the shape of a V over the surface of the boiler. The former type admits of the burner being placed much closer to the boiler than the latter, but is only suitable for burning a highly purified spirit. See Steam Car.

Bus—An abbreviation of Omnibus seen in the words autobus, motor-bus, etc.

Bushing—A cylindrical piece of metal used to form a bearing and held by the casing carrying the revolving shaft. Bushings are used to enable the wear in a bearing to be easily taken up, either by renewing the bushing in the case of small ones, or, in the case of large ones, by drawing the bushing tighter on to the shaft by means of bolts, the bushing being split longitudinally for the purpose. In this case the two parts are sometimes termed brasses. See Brass. Large bushings are generally made of alloys of copper or patent anti-friction

alloys. Smaller ones are usually made of case-hardened steel. Slight shake in the bearing shows that the bushings want renewing, a job that should be done by a competent man, as the fitting of a new bushing is a delicate operation. See Bearings; Repairs and Adjustments.

Butterfly Nut—See Bolts and Nuts.

Butterfly Valve—See Valves.

Buzzer—An electrical warning device used in place of a horn or hooter. It consists of a diaphragm in a conical sound-directing horn of metal. The diaphragm is made to vibrate rapidly by an electro-magnet in many respects like the trembler of a coil. (See Coil.) The electric current for operating it is generally obtained from a battery, a push button for completing the circuit being arranged on the steering wheel.

Buzzing—The action of the induction coil vibrator indicating that the electric circuit is closed.

By-pass—A form of cock or outlet which permits water steam, etc., to be directed to one of two channels, or allows of a portion of the fluid, etc., being diverted in both directions. Used on steam cars in the delivery pipe from the pump. It allows the water to be either forced into the boiler, or returned to the supply tank; or a portion can be turned into the boiler, the surplus passing into the tank. Often a by-pass is used to divert a portion of the exhaust gases for heating carbureters, and in some cases for automatically adjusting these by means of a piston or diaphragm against which the deflected exhaust gases press. See Steam Car; Carbureter.

C

C.—Abbreviation of Centigrade, as a temperature of 96 degrees C.

C. G. S.—Abbreviation of centimeter-gram-second, applied in mechanics to a system of physical units in which the centimeter is taken as the unit of length, the gram as the unit of mass and the second as the unit of time.

Cab—A four-wheeled inclosed vehicle for public hire or private use. A hansom cab has a single seat for two passengers with a driver's perch behind and above the body. The word is seen in auto-cab, taxicab, etc.

Cable—A large, strong rope or chain; in electricity, a heavy wire or strand of wires protected by insulating material and an outer covering, as by coils of coated iron wire.

Cadmium—A metal resembling tin in color and general appearance and used as an alloy for bearings and in the manufacture of electric batteries.

Cages or Valve Nuts Not Tight—See under Loss of Power.

Calcium Carbide—A brittle, grayish substance, obtained by fusing lime and carbon by electricity. When water is added to calcium carbide, a pungent gas called acetylene is rapidly given off and great heat produced. A residue of lime is left. Acetylene gas burns with great brilliancy, giving a beautiful white light. The gas when mixed with a certain proportion of air is highly explosive. Carbide is extremely sensitive to moisture, and gas is readily given off. The carbide should, therefore, be packed in airtight tins, and stored carefully. See Lamps.

Calcium Carbonate—The mineral calcite, the principal component of limestone, marble, and the chalk deposits. Frequently found in the water of rivers and wells, it deposits a crust after use in steam boilers, radiators, etc.

Calcium Chlorid—A substance used in anti-freezing solutions, having a very low freezing point.

Calibrate—To determine caliber, as that of a thermometer tube; or to determine relative value, as of the different parts of a graduated scale. The calibration of a thermometer tube is accomplished by inserting a column of mercury of known length and testing its length in all parts of the tube.

Calipers—An instrument for measuring diameters. Different forms are used for measuring inside and outside diameters.

Caloric—Pertaining to heat or the principles of heat. Ericsson applied the term caloric engine to his improved air engine, to distinguish it from other air engines on the same principle. The term is generally applied to hot-air engines.

Calorie—The unit of heat often employed in physics instead of the British thermal unit. It is the quantity of heat necessary to raise the temperature of a kilogram of water from 0 to 1 degree centigrade. The small calorie or unit of heat on the C. G. S. system is the heat required to raise the temperature of one gram of water from 0 to 1C.

Calorimeter—An instrument for measuring the quantities of heat given off by a body under varying conditions.

Cam—An irregular disk, designed to produce a reciprocating or variable motion in another part. It is mounted upon a shaft (see Shafts) with which it revolves. It may be a circle having a projection upon it which will lift the part to be operated once in every revolution of the cam; or it may be a circle having a notch cut in it, into which the part drops once in every revolution. Besides these there are many other forms of cams.

A form largely used in motors for lifting valves has a little more than half of the circumference concentric to the shaft, upon which it is mounted. At a certain point the contour assumes a straight line and this constitutes the lifting stroke of the valve, and for awhile the valve is held open. After passing another point the valve closes and remains closed until the starting point is again reached. It will thus be seen that in one revolution of the cam the portions which are concentric to the shaft produce no motion; at the same time the amount

of motion produced by that part which projects from the center can be regulated by the distance at which it is placed from the true circle. Another form of cam would gradually open and suddenly close a valve. There is no motion where the contour is concentric to the shaft upon which the cam is mounted.

In Fig. 1, a cam for lifting valves, the contour from "a" to "b" constitutes the lifting stroke; from "b" to "c" the valve is held open, "b" to "c" forming the segment of a circle which is concentric with the main outline of the cam. After passing "c" the valve begins to close, and so on.

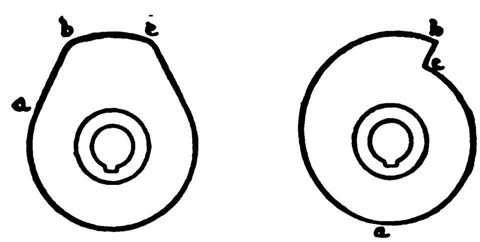


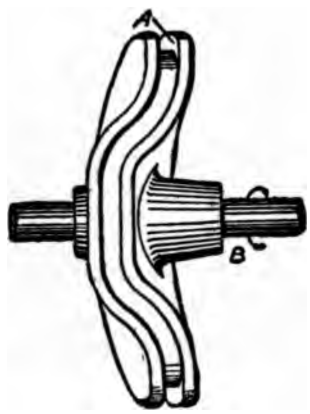
FIG. 1. CAMS. FIG. 2.

In Fig. 2 is seen a cam with which a gradual lifting action would occur from the point "a" to the point "b," and a sudden closing when the part in contact with the cam would suddenly drop to "c." From "c" to "a" no motion would be imparted.

Some makers utilize their cams to vary the lift of the valves by making the cam wide, and increasing in height or lift from one edge to the other. Now, if the shaft on which the cam is mounted is slid along its own axis, the height to which the valve is lifted corresponds to the height of the part of the cam which is lifting it. In this way the valve can be left wholly shut by leaving the lowest profile of the cam quite circular, the cam revolving the whole time. Some use cams which act on the exhaust valve in this manner. The cam is slid along under the valve until a profile comes into operation which in the medium position gives half compression, and at the extremity of the range of movement opens the exhaust

valve on every down stroke and closes it on every up stroke. Meanwhile at the extremity of the range of movement the inlet valve cam ceases to act, and the valve remains closed. In this way the engine is used as a brake for the car. Some high-powered cars have a small hand lever fitted near the starting handle, which lifts the exhaust valves slightly, giving a lower compression, so as to enable the person starting the engine to do so without undue exertion.

Besides the cams which we have described there are edge cams provided to give a variable movement in a direction parallel to the shafts on which the cam is mounted. For instance, the lever or rod which the cam operates is provided with a roller which runs in a groove, which, while always being concentric with the axis of the shaft is of an irregular shape, approaching alternately one or the other end of the shaft as the motion required demands. It is used sometimes in motor car work for operating the forks which control the sliding gear wheels in the change speed gear.



An Edge Cam.

A, Slot in the Profile of Cam, Giving Motion to a Lever Resting in the Slot. B, Shaft on Which Cam Rotates.

Another type is the edge cam in which a lever presses on the face of a disk having protuberances which cause the lever to move away from or nearer to the face of the disk.

In this case the lever must be kept in contact by some form of spring. It is used for contact breaking on some forms of magneto ignition machines. See Ignition.

The cam must not be confused with an eccentric, which is a true circle mounted upon a shaft, out of its own center.

Camber—Any convexity upon an upper surface, as the curve of a ship's plank, etc.; applied to the bend of an axle designed to tip the wheels.

Cambered Frame—The frame of a motor car made narrower in front to permit of greater facility in turning.

Cambered Live Axle—See Axles.

Cambered Road—A road having a convex surface; also called barreled road.

Cambered Wheel—See Wheels.

Cam, Edge—See Cam, above.

Cam, Exhaust—A cam which lifts the exhaust valve.

Cam Gear—The gearing which drives a cam-shaft.

Cam-head—The projection or nose on a cam disk.

Cam, Ignition—A cam employed in an ignition system.

Cam, Inlet—A cam employed to operate an inlet valve.

Cam-nose—Same as Cam-head.

Camping—See Touring.

Cam, Reversing—A cam by means of which a motor can be reversed.

Cam-shaft—A shaft having tumblers or wipers to produce irregular speed or motion, etc.

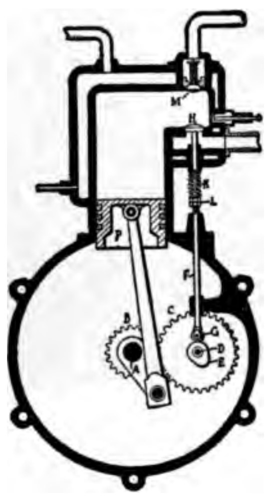
The "half speed" or "half time" shaft, fitted with a cam or cams, which operates the inlet and exhaust valves of an internal combustion engine. See Cam above.

Use of the Camshaft.

In a gasolene motor the camshaft is used to open the intake and exhaust valves, to allow the explosive mixture to enter and allow the exhaust gases to escape. In many motors one camshaft opens the intake and exhaust valves, whereas in

others there is one camshaft to open the intake valves and another to open the exhaust valves. Besides opening the valves the cams on the camshaft determine how long the valve remains open and the speed with which it opens and closes. The accompanying illustration shows how this is accomplished, it representing a single-cylinder motor as seen with the cylinder cut vertically in two.

In this illustration A is the crankshaft, which is revolved by the explosions in the cylinder, forcing the piston P downward. The camshaft is marked D and carries a cam or raised bump



Camshaft and Its Location.

E upon it, the cam being pinned in place. The camshaft is driven at half the speed of the crankshaft through the spur gears B and C, the gear B being one-half the size of C, consequently driving C at but half of its speed. The valve to be opened is H, which in opening has to be lifted off its seating. This is done when the cam E revolves and rises against the roller G, which is on the bottom of the lifter rod F. The rod F extends upward and rests against the bottom of the stem of the valve H, although between the two or at their point of contact are nut and locknut L for

lengthening or shortening the lifter F, and so to vary the time of opening or closing of the valve. The spring K is compressed or squeezed together when the valve is opened and immediately the cam E travels around and allows the roller G to fall; this spring exerts its pressure and closes the valve. Directly above valve H is the intake valve M, which in this case opens by moving downward. This valve is automatically opened, not requiring aid from a camshaft. It is opened by the suction of the engine, the same as the valves in the common water pump.

The majority of the camshafts are made with the cams E separate from the shaft, but of late not a few of the best make of cars employ camshafts in which the cams are solid with the shaft. This is a more expensive construction, but there is not any danger of the cams getting out of position.—Motor Age.

Cam, Snap—A cam in an ignition system which operates to close the circuit.

Candle-power—The illuminating power of a standard candle taken as a unit of luminosity; as, a lamp of 64 candle-power. The standard generally used is a spermaceti candle burning at the rate of 120 grains of sperm an hour.

Canopy—In automobiles a top that does not fold up.

Caoutchouc—India-rubber. See Rubber.

Cap—Any cover used to protect working parts from dust or dirt, such as the oil cap of the road wheel axles, which are screwed into the boxes of the wheels, and while serving to hold a supply of grease or oil for the lubrication of the axles, prevent the entrance of any dirt. Dust caps are placed for the same purpose over many parts of the machinery which have to be oiled.

Capacity—The ability to absorb or contain; used in connection with oil or water tanks, etc., and with accumulators or batteries and dry cells; for example, a tank of 5 gallons capacity, an accumulator of 20 ampere hours capacity, that is, capable of discharging at the rate of 1 ampere for 20 hours, or 5 amperes for four hours.

Capacity, Cylinder—The volume or cubic contents of a cylinder, especially that between the maximum and minimum stroke of the piston.

Capacity, Electrical—The capacity of a conductor is the quantity of electricity required to raise its potential from zero to unity. The unit of capacity is the farad.

Cape Apron—A variety of storm apron for motor vehicles.

Cape Hood—A long extension hood or top for a motor vehicle. Those who for the first time drive a car fitted with a Cape hood should bear in mind that it is considerably wider than the car, and when passing large wagons or other wide vehicles, this fact should be remembered.

Capillary—Having a hair-like bore, on account of its fineness.

Capillary Attraction—The phenomenon exhibited by liquids of clinging to surfaces and fine tubes. It is considerably affected by the nature and shape of the surfaces. The absorption of moisture by sponges, sugar, salt, etc., are examples of capillary attraction. In some of the earlier carbureters the capillary attraction of a wick was availed of.

Car—In automobiling, a term applied generally to any form of motor carriage. In aeronautics, the basket or other device in which the aeronaut rides.

Carbide—See Calcium Carbide.

Carbon—An element found in nature in distinct forms, as the diamond, which is extremely hard, and graphite, which is very soft, black and opaque. In combination it is universally distributed and enters into the composition of every living tissue. By the action of heat it assumes amorphous forms, such as charcoal, lampblack and gas carbon. It is widely used in the automobile industry, and in electrical apparatus is indispensable, forming the positive electrode of most primary cells.

Carbon, Gas—A hard form of carbon deposited in gas-making retorts and used in electrical manufacturing, for electrodes, etc.

Carbon, Removing—An annoyance with which almost every motorist has to contend more or less is the deposit of a hard, indurated form of carbon, similar to gas carbon, upon the walls of the cylinders and valve chambers. This carbon is a product of heat decomposition of the fuel or the lubricant, or both, under pressure, and in the presence of too little air for combustion. Its formation can be avoided almost altogether by close attention to the lubrication, valve and ignition timing, and carbureter adjustments. According to Motor Age, too rich a mixture almost invariably results in carbonization, which also follows upon the use of oils that do not stand high enough temperatures, or that are otherwise of poor quality. Likewise, delayed opening of either exhaust or inlet valves, in the one case not providing free exit for the exhaust and in the other cutting down the time for combustion, will tend to produce carbonization. Unduly late ignition produces an effect similar to that of delayed inlet-valve opening, by reducing the time for combustion.

It is not possible, however, to avoid carbonization altogether, and even in the best cars, perfectly adjusted, the deposit will slowly accumulate. To keep it to a minimum, the often recommended process of coal-oiling the cylinders from time to time is to be advised, but even with this preventive regularly applied it occasionally becomes necessary to take off the cylinders, scrape out the combustion chambers and clean off the valves and pistons. Otherwise, sooner or later, according to the quality of the engine and the perfection of its adjustments, serious trouble will be caused by the accumulation. For one thing, as soon as it is present in points or lumps, these will tend to become red hot and thus occasion pre-ignition. Small particles, too, may catch on the valve seats, holding the valves open and causing loss of compression and power or if the valve heads are of the cast iron type, their breakage by the forced uneven seating. The carbon that catches in the piston rings and their grooves may so bend the rings as to prevent their even contact with the cylinder walls,

so essential to good compression, and in addition may badly score the cylinders.

In scraping off these carbon deposits it is necessary to use hard, sharp-edged or pointed tools for scrapers, and to apply them vigorously and thoroughly to every part that presents the objectionable coating. For cleaning out the ring grooves it usually will be found desirable to expedite the work by grinding a special tool, made to fit so closely as to leave no deposit under its end or by its edges. Keeping the deposits moist with kerosene will facilitate their removal; soaking them with kerosene for hours or even days will be still better.

For surfaces that can be reached in this manner, and that will not be injured by the wear it will cause, finishing may be done with coarse emery cloth, held in the hand or around a stick, as circumstances may require. It is to be understood that it is a rather long and tiresome job at best, to thoroughly clean all parts of a badly-carbonized engine, but the improvement in its power and running afterwards will more than compensate for all the work expended by the owner.

Carbon Monoxid—A poisonous gas, C O, developed in the combustion of carbon, coal, etc., and emitted from the exhaust pipes of motor engines. Care should always be taken not to inhale it. Carbon dioxid is carbonic acid.

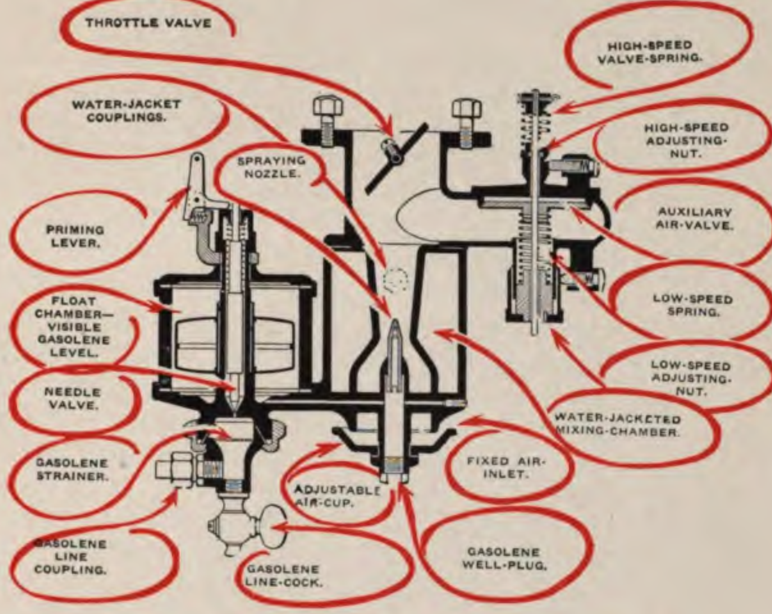
Carbonize—To convert into carbon or to combine with carbon, as in the manufacture of steel; to carburize.

Carborundum—A very hard compound of carbon used as emery powder for grinding, etc. Deposits yielding carborundum have recently been found in several parts of the United States and it is becoming increasingly useful.

Carburation—The saturation of air with a hydrocarbon such as gasolene, naphtha, or petroleum, in such proportions that an explosive gas is the result—the function performed by the carbureter.

Carburation—See under Overheating.

Carbureted Air—Air which has had a certain proportion of the vapor of gasolene, alcohol, or such like hydrocarbon es-



Details of Stromberg Type Carbureter.

sence mixed with it to form an explosive mixture. Given a fixed quantity of such vapor the proportion of air is not always the same, as it varies somewhat with the temperature of the air and the amount of moisture contained in it. To overcome this it is usual to draw the air in through a heated chamber, or cause it to pass around the hot exhaust pipe before being drawn into the carbureter. This is effective in keeping the proportions fairly constant. See Carbureter.

Carbureter—An apparatus used to transform the liquid fuel, generally gasolene, into a gas, and at the same time mix it with such a proportion of air as will make it combustible, so that it can be used in a gasolene engine in the same way as ordinary coal gas and air are used in a gas engine.

We may use two different methods to obtain a gas from the liquid fuel. We may draw air through or over the surface of the gasolene and thus vaporize it, or we may spray the gasolene into the air. In either case we have made the gasolene combine with the air so as to form an explosive gas.

The Surface Carbureter.

When we draw air through or over the surface of the gasolene we have what are known as surface carbureters, and these can be divided into three classes:—

1. The type of carbureter in which air is drawn over the surface of a body of liquid fuel and, evaporating, carries off with it a certain proportion of that liquid.

2. The type in which the capillary action of a wick is utilized, and the air is drawn through that portion of the wick above the level of the liquid and carries off with it the evaporated gas.

3. The type in which air is drawn through the liquid.

All these types are practically obsolete as far as automobile work is concerned. The surface type of carbureter is undoubtedly one of the most economical, but it fails through being incapable of rapid alteration of mixture, and on that account has been practically discarded for motor car work.

The Lanchester (English) surface carbureter consists of

a large circular bundle of wicks threaded out at their lower ends, these ends being immersed in gasolene in a large inclosing tank. Warm air is drawn through the upper portion of the bundle of wicks, and coming in contact with the gasolene drawn up by capillary attraction, becomes charged with gasolene vapor, the actual proportioning of the mixture being determined by means of an air cock admitting more or less air to the passage which conducts the mixture from the wicks to the engine. The Ader type, also still in use in Europe, is much smaller, but has materially the same action as that of the Lanchester.

The bubbling or ebullition type of carbureter is another arrangement which though at one time largely used, has now been entirely abandoned for automobile work. The only case extant of this type is a carbureter for crude petroleum. In this device warm air is bubbled through oil heated to ebullition by the exhaust from the engine, and so becomes charged with petroleum vapor.

The Float-Feed Carbureter.

The spray or "float-feed" type of carbureter is now almost universally used. The term atomizer more nearly describes the action of the spray carbureter than any other term. When we force gasolene through a small orifice so that it comes out in the form of a spray we practically break it up into tiny atoms, which are mixed with the air current which causes the spray. These atoms of liquid fuel rapidly become vaporized, and the result is a gas mixture which is highly explosive. The different spray carbureters vary from each other mainly in different means adopted for proportioning the gas and air mixture for different conditions and different speeds of the engine.

With this construction gasolene is kept at a constant level in a jet nozzle by means of a float-feed device. The suction of the engine causes air to flow past the jet, and the vacuum set up produces a flow of gasolene from the jet, this flow being maintained during the suction stroke as a very fine

spray. In this finely divided or atomized condition the gasolene is readily evaporated and taken up with the inrushing air through the inlet pipe to the motor. Generally there are provisions made for admitting more or less air to the mixture after it comes from the jet, or spray chamber, this arrangement being necessary in order that correct proportions of gasolene to air may be approximately maintained.

The multiple jet type of carbureter is a development of the ordinary jet or spray pattern. With it there are a series of jets having various sizes of nozzle. The smallest is used at the lowest speed of the engine, while the increasing diameters are used either separately or in conjunction with the preceding jets as the speed of the engine is increased; it being evident that at a low speed, unless a very fine orifice is provided, the spraying effect will not be obtained, while with increasing speed and suction it becomes necessary to increase the area or orifice in order to get the requisite amount of gasolene through.

Originally all carbureters were made with a mixture supply and a source through which additional pure air might be drawn, and regulation was accomplished by opening or closing this supplementary air supply from the driver's seat, the accomplished results, of course, being in accordance with his skill.

In the early days of the 20th century, Krebs, a French engineer, invented what may be termed the first automatic carbureter in which the mixture was regulated automatically by the speed of the engine; flexibility being thus obtained to an extent hitherto undreamed of. This invention paved the way for, and inspired, a vast number of others of greater or less merit, but it also gave rise to one theory that has since been proved erroneous, namely, that in order to obtain the best results the engine should be fed by a carbureter which automatically keeps the proportion of air to gasolene always the same. It was on this principle that the majority of designers worked, and the result was that for a considerable

time there was a deadlock in carbureter design. Every one had in view an erroneous condition and, where their efforts to satisfy this condition were the most successful, the actual results obtained were the poorest. Experience since derived indicates that in order to obtain maximum flexibility from an engine the mixture must be slightly richer in gas at low speeds, while it may have increased air proportion as the speed develops. It is on this principle that most of the carbureters fitted to modern machines now operate, although such operation is very largely obtained automatically from the engine speed.

In all spray carbureters it is necessary to provide means of

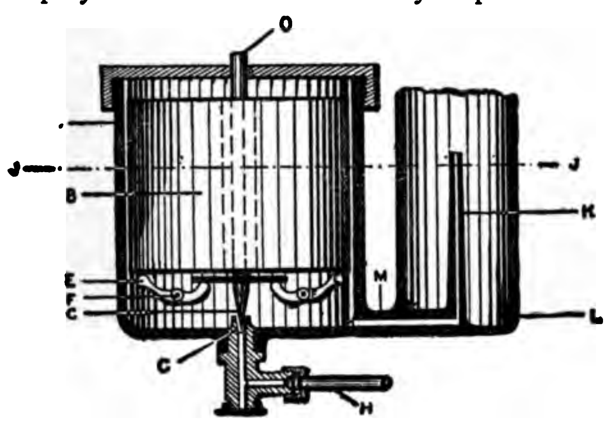


Fig. 1—Carbureter Float Chamber and Jet.

keeping the gasolene at a constant level. If it were fed direct from a tank to the spray nozzle it would have a constantly varying weight of liquid behind it, as the tank was filled up or emptied. This would result in varying sprays, irrespective of the varying suctional effect of the engine at different speeds. It is desirable that the inertia of the fluid from which the engine sucks the spray shall be constant, so that some constant level device becomes necessary.

The float feed meets this requirement, and is practically the same in all types of carbureters.

A diagrammatic view of the float mechanism is given in

Fig. 1. A is the float chamber, supplied with gasolene through the inlet H. C is a needle valve, shutting off or opening the gasolene inlet. There is a collar around the needle valve, the weight of which keeps the latter normally closed. B is a float formed of a hollow chamber of light brass or other metal which floats in the gasolene. M is the outlet from the float chamber conducting the gasolene to the spray jet K in the spraying chamber L. The level of the gasolene normally stands at the height of the line J J, that is to say, just below the top of the spray nozzle K. When gasolene is sucked through the nozzle K by the engine the level of the gasolene in the float chamber is lowered, and the float descends. In doing so it comes in contact with the top ends of the levers E E pivoted at the points F F, and depresses them. The bottom ends of these levers then come in contact with the collar on the needle valve spindle, raising it and admitting more gasolene until the level is regained. It will be seen that the action takes place automatically, and the level of the gasolene in the float chamber and in the spray nozzle is retained at a constant point. This device is common to practically all spray carbureters, and whether the gasolene is supplied by gravity from a tank higher than the carbureter, or forced under air pressure from a tank at a lower level, does not in any way alter the working of the device.

The Longuemare Carbureter.

We may now deal with a few types of modern carbureters. One of the best known is the Longuemare, several models of which are made. Fig. 2 shows the automatic type; A is the float chamber containing the float B; F is the needle valve, normally closing the entrance for gasolene through the intake pipe H, I being the union for the pipe connecting it to the gasolene tank, and J being a drain cap. The two pivoted levers G G act, as we have already described, on the needle valve F, and keep the level of the liquid constant. The gasolene flows from the float chamber to the tube M inside the spray chamber N. The top of the tube M is cone-shaped, and a conical plug L is screwed down to seat on the end of it.

All round the edge of the plug L are grooves which form a number of radial spray jets, the suction of the engine drawing out the gasolene in fine sprays in the direction indicated by the arrows.

Around the vaporizing chamber N is an annular chamber V, which is supplied with hot air from the exhaust pipe through the union U. The air entrance is at the bottom, the air being sucked in through the opening X and rising around

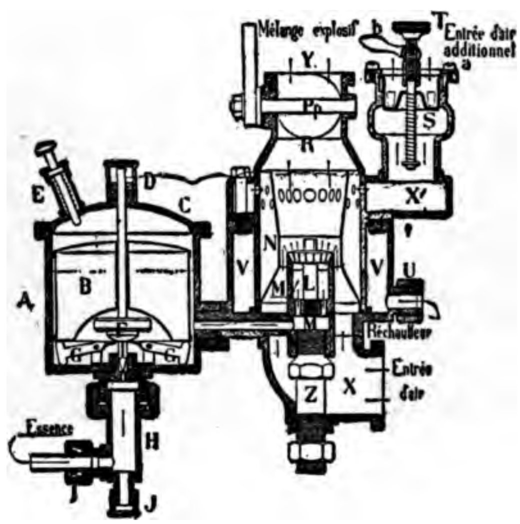


Fig. 2—The Longuemare Carbureter.

the spray tube M. It is kept close to the radial sprays of gasolene, by the circular baffle shown, which takes the form of a double inverted cone.

Around the top of the spray chamber is a second annular chamber X^1 in connection with the supplementary air inlet valve S. This valve S is kept normally closed by a light spring as shown, and the tension of this spring can be regulated by the milled thumb nut T and the lock nut b. When the engine speed, and consequently its suction, exceeds a determined limit it not only draws in the air and gasolene from

the bottom of the spray chamber but also opens the valve S and draws in an additional supply of air which enters the spraying chamber by way of the holes shown in X^1 and mixes with the ascending gas charge, which passes out through the outlet Y, in which is situated a butterfly valve or throttle P.

It will be seen that if the throttle is closed partially the suction of the engine will not be enough to open the supplementary air valve, and a rich mixture will result. With the throttle open and the engine running fast, the supplementary air valve will come into operation and the most economical mixture will be obtained.

The Krebs Carbureter.

The next typical carbureter which we illustrate is the original automatic one previously mentioned, namely, the Krebs.

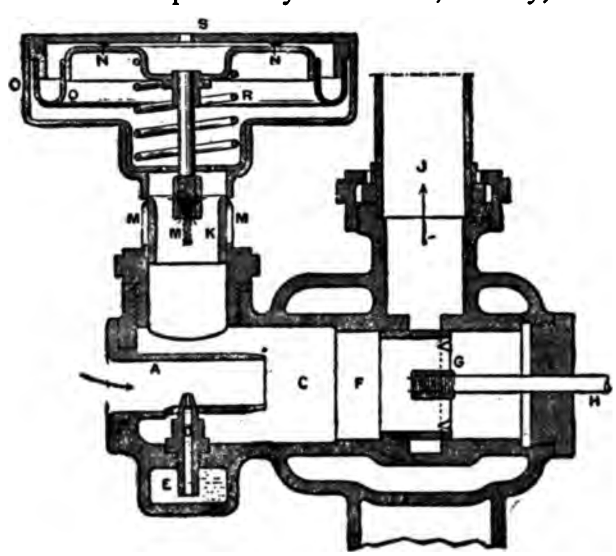


Fig. 3—The Krebs Automatic Carbureter.

In Fig. 3 E is the duct from the float chamber. D is the jet which protrudes through the wall of the air intake pipe A. J is the inlet pipe of the motor which is attached to the carbureter above the throttle chamber F, which takes the form of

an open headed cylinder in which a piston G slides, actuated through the rod H from the governor of the engine. The small V-shaped notches seen in one edge of the piston are so placed as to give a very fine adjustment of throttling for the engine at low speeds. Leading into the chamber C is a branch in which are cut additional air openings M M, the combined area of these being controlled by means of the piston K, which is caused to slide up and down over the ports M M by the suction diaphragm N located in the suction head marked O. The diaphragm is simply a shaped metal plate which is attached to the piston K by means of a rod, but it is normally kept in such a position by means of a spring marked R, that the piston K covers the ports M M, as shown in Fig. 3. The joint between the diaphragm plate N and the walls of the suction head O is by means of an annular rubber ring Q, which is free to rise and fall with the diaphragm plate. In the illustration the throttle is shown in the extreme shut position, and the piston K fully covering the ports M M. Of course in such a position the engine would not run at all, but supposing the throttle piston G were to be moved a little to the left, so as to give a slight throttle opening, all the air would be passing through the tube A over the surface of the jet, and the ports M M would still be covered. Supposing now that the throttle be opened wide, and the speed of the engine increased accordingly, the suction within the cylinder C and also beneath the suction plate N will become more intense, with the result that a sucking down of the piston K occurs, and the ports M M are uncovered in proportion to the amount of suction, their area being so calculated that the amount of air which they admit to the mixture formed in A and passed on to C just forms a correct mixture for the engine to run most flexibly upon.

There are a large number of carbureters similar to the Krebs in principle.

Automatic Carbureters.

Much may be said regarding the modus operandi of modern mechanical automatic carbureters. The mechanical action

whereby the carburation is corrected in accordance with the speed of the engine may be derived in various ways. Thus in the Peugeot spraying carbureter the manufacturers alter their air inlet through the medium of a centrifugal governor. Others merely interconnect the air inlet and the throttle, this being a method employed by the Daimler company.

The Rover Carbureter.

One of the most ingenious, and at the same time the simplest, of these modifications, was that adopted by the Rover Company of England in their carbureter, which con-

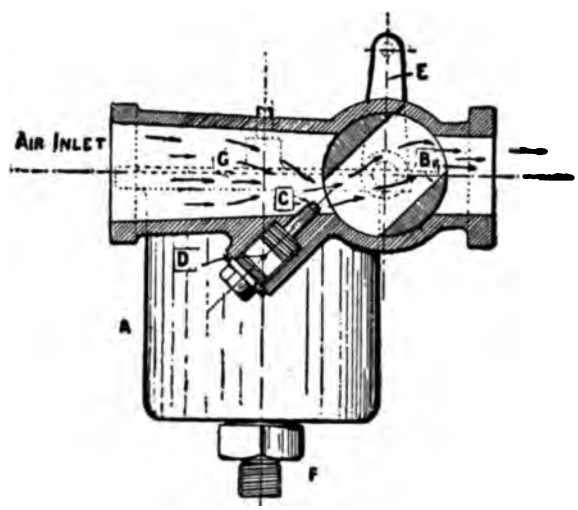


Fig. 4—The Rover Carbureter.

sists simply of a cock which has the jet located within its plug portion, so that as the throttle is closed the air is also shut down. The illustration is practically self-explanatory.

A is the float chamber into which the gasolene is introduced through the union joint F. The gasolene emerges from the float chamber through the hole D, and passes up through the spray nozzle C. This is set at an angle in the tapered air pipe G. The air enters from the left and is sucked through the air pipe by the suction of the engine in the direction of

the arrows. The gradually decreasing area of the air pipe causes the air to flow more rapidly and with an accelerated movement as it nears the narrowest part of the air pipe, at which point it sweeps past the spray nozzle, which is inclined in the direction of the air current. It will be seen that immediately at the right of the air pipe is a rotating plug B which is operated by the lever E. When this plug is turned fully open the air has a clean run through, and, of course, draws a spray of gasolene through the nozzle C, the spray mixing with the air charge, and being carried on to the engine in the form of combustible gas. If the plug is turned into the position shown in the diagram the air passage through is throttled and at the same time it has to pass down nearer the spray nozzle. This has the effect of causing an approximately richer mixture than would be the case if the throttle were put on the inlet pipe somewhere close to the engine, and in a position where its edge could not deflect the air down over the spray nozzle. The plug B, therefore, causes a more constant mixture to be obtained, whether the engine is running with the throttle fully open or partially closed. The arrows indicate the direction of the air, and show how, when partially throttled, the whole of the air has to pass directly around the orifice of the spray nozzle.

This practice of admitting the whole of the air from an orifice behind the jet, so that it must necessarily pass the gasolene nozzle on its way to the engine, has grown largely with regard to carbureter design.

Thus in one European carbureter there is a cam arranged opposite to the jet in a circular chamber of rectangular section, so that as the cam is rotated in conjunction with the throttle valve the area of opening past the jet is accordingly increased. In two or three other types cones are moved vertically about the jet, so that the necessary expansion of air orifice is attained. When, however, mechanical carbureters are used they are never connected to the engine governors, a practice almost invariably found where a suction automatic carbureter is employed.

Multiple Jet Carbureters.

Multiple jet carbureters are often employed, particularly where a large range of flexibility is aimed at. In most of them there are from two to four jets which are unveiled to the incoming air in turn, and are either used one at a time (the commencement of a second jet causing a cessation of the first), or else in a series. In one of the simplest and most novel the spraying nozzle runs obliquely from the corner of the float chamber into the spraying chamber, and contains inside it a loose toothed rod, with some five or six serrations. In order to reach the spraying chamber the gasolene has to pass over the serrations cut in the rod, and these offer a certain amount of opposition to its passage. When the speed of the engine increases and the suction becomes great, the rush of the gasolene is interfered with to a greater degree than when the speed of the engine is slow and the suction is slight. In other words, when the gasolene dashes up against and into the angle of these serrations, the stream doubles back on itself, so to speak. Approximately correct mixture is therefore maintained at all engine speeds. Different sized toothed rods are supplied with each carbureter, so that the motorist can experiment for himself until he gets the best results.

Functions of the Carbureter.

In answer to the question of the novice, "What does the carbureter do?" it may be said broadly that the carbureter brings together a portion of liquid gasolene with about 8,400 times its volume of air, divides the liquid up into so fine a spray that the mixture of the air and liquid is made very intimate and complete, and provides means for keeping this mixture correctly proportioned under the varying working conditions of the engine.

Essential Parts.

The essential parts of a typical float-feed carbureter may be stated as follows:

1. A small pipe which supplies gasolene to the float chamber.

2. A float which, when raised by its buoyancy, inserts a needle into, and thereby closes the small supply pipe.

3. Another small tube which leads gasolene away from the float chamber to the spray nozzle.

4. The spray nozzle or jet which squirts the gasolene into the middle of the stream of air which is on its way to the engine.

5. The air duct along which the air (which is very often hot air) is made to pass when the engine makes its suction stroke. The parts of this air duct are called by different names, as follows: From the place where hot air enters a gauze filter at the mouth of the duct up to the near neighborhood of the jet, it is perhaps most usually called simply the hot-air pipe and is often made of copper. All round about the jet itself the shape of the duct generally changes. It is called the spray chamber, and is usually made of cast brass. Beyond this, from the spray chamber to the engine, it is called the inlet, induction or mixture pipe, and is sometimes made of copper, though sometimes it is a casting.

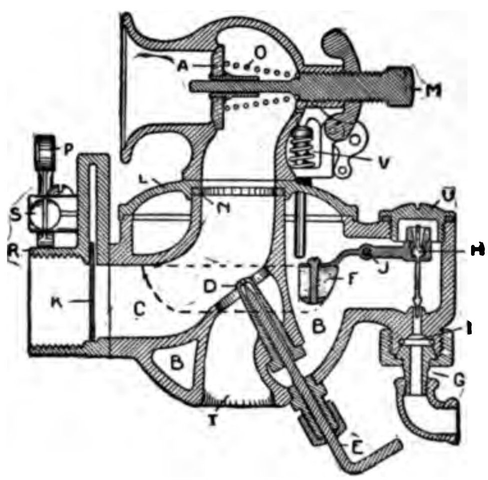
6. In the length of the mixture pipe is often inserted a device called the auxiliary air valve. This is an automatic device introduced to secure the different qualities of mixture gas required under the varying conditions of travel.

7. Further on in the length of the mixture pipe is the throttle valve, which the driver can open or close at will by moving a small handle somewhere on the steering column.

Quality of Mixture.

The automatic extra air valve was introduced to give to the engine at high speeds a diminished quantity of gasolene per stroke. This fact is often stated differently, namely, that it was introduced to give more air at high speeds than at low speeds, but this is the wrong way to put it. More air is available, but it is not and cannot be taken by the engine, for reasons which will appear later. Agreeing for the moment

that from 40 per cent. to 25 per cent. less air per stroke is taken in at high speeds with or without an automatic valve (at, say, 1,500 revolutions), than at low speeds (say, 150 revolutions per minute). This taking of less air per stroke is the chief and first reason why less gasolene per stroke must be



The Schebler Carbureter—Model E—Section.

A Compensating air valve
B Float chamber
C Mixing chamber
D Spraying nozzle
E Needle valve
F Float
G Reversible union
H Float valve
I Float connection
J Float hinge
K Throttle
L Float chamber cover
M Air valve adjusting screw
N Cork gasket
O Air valve spring
P Throttle lever
R Pipe connection
S Throttle stop
T Fixed air opening
U Float valve cap
V Flushing pin

given if we wish to maintain what may be called the normal proportions of mixture. Notice here that we cannot hope to avoid the taking of less air even by making smoother and larger air passages and valves, since the chief impediment is not the friction of the air against the pipe walls, but the inertia and elasticity of the air which prevent our giving it

the necessary acceleration in the short time of a suction stroke when the engine is going fast.

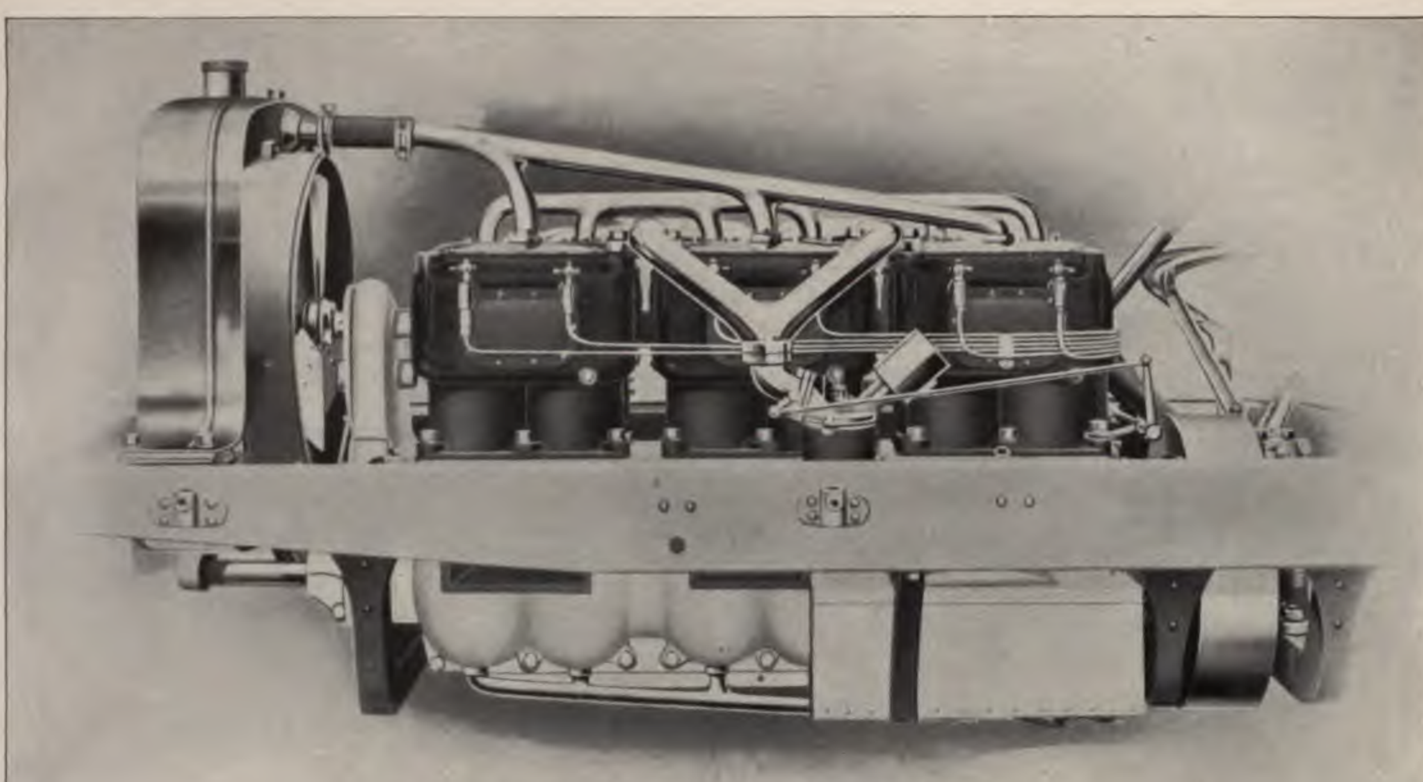
Reason 2.—Besides this chief reason, there are subsidiary reasons why less than the normal flow of gasolene per stroke is wanted at the highest engine speeds. Thus there is increased compression at high speeds, and this affects the matter of the most desirable mixture very appreciably. The volume sucked in is about one-third less, but the compression is effected ten times faster, and this means a hotter compression, and therefore a higher compression, than if the same amount of gas were compressed in the same engine more slowly. To prove this, consider the two extreme cases of speed, namely, infinitely slow and infinitely fast. The difference of pressure can be calculated, and it is enormous. In an engine of which the ratio of compression was only 3.63 to 1, 42 lbs. compression was calculated in the one case, and 89 lbs. in the other, taking a supposed full charge of air in each case.

If the engine of the example had had the usual "five-to-one" compression ratio, this would mean bad pre-ignition with a normal mixture, and a poorer mixture automatically given would be necessary to save the situation at high speeds, unless we submit to the inefficient process of diminishing the compression by strangling the volume of incoming gas.

There is also another fact which operates in the same direction as the last, namely, the diminution of all small leakages of gas past the piston rings and valves, spark plug, inspection cock, plugs and joints, when the stroke is rapid, all making for an increased compression, and therefore, from a carbureter point of view, all pointing to the desirability of a poorer mixture and therefore an extra air valve.

Reason 3.—The high and hot compression is further enhanced by the incomplete discharge and high temperature of the unexpelled residue of the exhaust from the previous stroke, and the consequent greater initial temperature of the heterogeneous mixture which constitutes the explosive charge.

Reason 4.—Still another reason for requiring at low speeds



Carburetor Side of the Winton Six Motor

more gasolene than the average per stroke, and incidentally therefore for requiring an automatic valve or its equivalent, is based on a totally different consideration. At the limit of slowness with a normal mixture we fail, even with a retarded ignition, to keep the engine rotating, because of the evanescent character of the explosion pressure and the failure to ignite, or at least the incomplete inflammation of the charge, which would be much throttled down for slow turning, and therefore poorly compressed. But we find by experiment that a slightly more durable explosion pressure is secured, and much more certain ignition is obtained, when the mixture is rich in gasolene. We therefore decide to employ a rich mixture when running slowly and to put up with the drawbacks of a rich mixture, which are that we do not get complete combustion of the gasolene. We take the risk of a little smell and waste of fuel for the sake of having a "flexible engine."

There are many other ways of regulating the quality of mixture besides the use of the automatic or auxiliary air valve. It is largely a question for the engineer. The engine and the carbureter must be "tuned up" together to secure the best results.

One important practical condition amongst many has already been mentioned—it is known popularly as the condition which shows up the "flexibility" of the engine.

A "flexible" engine is one which continues doggedly to do a modicum of useful work when rotating quite slowly. The term "flexible" does not exactly fit the case, but it has become established. This property is assured not only by having the rich mixture at low speeds but also by increasing the number of cylinders, using mechanically operated inlet valves, increasing the size of the compression volume in relation to the piston displacement, etc. These engine matters again bear upon carbureter design, because they affect the rate at which the gas is called for and the manner and frequency of that call—proof again that engine and carbureter must be fitted to one another as carefully as a boot to a gouty

foot. It is quite interesting to summarize the number of evils which, though sometimes due to other causes, may often be due to a badly adjusted carbureter. Sooted spark plugs, boiling of radiator, eroded exhaust valves, loss of power, misfiring, waste of gasolene, failure to pick up until some moments after any new position of the throttle has been adopted, smelly exhaust, "popping" behind the inlet valve, explosion in the exhaust box, pre-ignition with resultant damage to crank-shafts or connecting rods, failure of the engine to stop when the spark has been interrupted, etc., etc.

In view of all this, it is small wonder that manufacturers have been kept busy experimenting with innumerable methods and suggestions for varying the quality of the mixture in some manner remotely according to the conditions of its employment.

A Cause of Heavy Gasolene Consumption.

One source of excessive gasolene consumption is the heating of the carbureter to a much higher degree than is necessary, so that, independently of the suction by the motor a comparatively large quantity of gasolene is drawn through the jet in the form of pure vapor. This added to the subsequet charge of gasolene drawn through the jet by the suction of the engine makes up the large quantity of liquid used. The resultant cylinder charge is, of course, much richer than is necessary or good for the engine, as sooty valves and plugs nearly always result. We use the words "nearly always" advisedly, as some engines have their valves and plugs so placed that they are automatically cleaned by the exhaust gases, one charge sweeping before it the soot deposited by the previous charge. Again, in other engines, the plugs, or, perhaps, the valves alone, are so placed as to prevent the accumulation of carbon deposit. We mention this, as probably some readers will wonder why their valves and not their plugs become dirty or vice versa.

Having given a probable cause of the trouble, we suggest a remedy which, to many readers, will be perfectly obvious,

and that is to cut off the hot air or water, as the case may be, from the heating chamber by means of a simple cock. It is only when running through a keen frosty air, or when the atmosphere is heavily charged with moisture, that the heating chamber is actually required, yet on many engines no provision is made for cutting off the source of heat, hence the increased gasolene consumption.

Letting in More Air.

There is no doubt that many cars waste a lot of gasolene simply because the carbureters do not supply sufficient air. In this matter, car owners might well take an example from motor cyclists. Speaking generally, motor cyclists realize the advisability of using as weak a mixture as possible, and after a motor cyclist has passed his novitiate it is quite the usual thing to find that he has so altered or adjusted his carbureter that he can always command an adequate supply of air, as very few cycles are turned out with provision for a full supply. It is not merely a question of economy of gasolene, though that is quite an item, but in many cases more power can be obtained from the engine, and it keeps much cleaner, while the valves keep cooler and the smell from the exhaust is much less if the weakest possible mixture is used. An extra air inlet is therefore a good thing and there are many ways of increasing the air supply.

Water in Air Pipe.

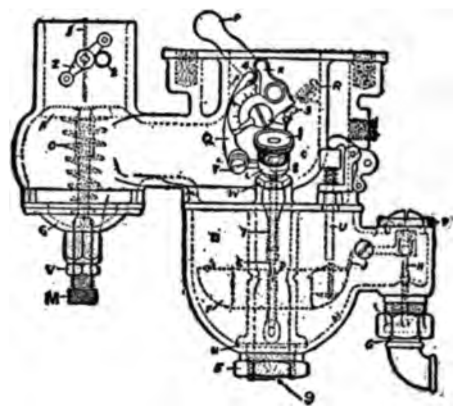
The air supply pipe to carbureters of most cars is arranged so that the pipe can be open to the air, or made to take its air from round the exhaust when the temperature of the outer air is so low that good running cannot be obtained unless the air be heated. On many cars the air pipe is high up and well out of the way, but there are a number which have the pipes so arranged that when the car is washed, some of the water may splash into it at the cold air slot. We have come across instances in which this has occurred, so that the water has been sucked into the carbureter; then if the engine does not run well, it has been assumed that there

was water in the gasolene, though, as a matter of fact, any small quantity which might enter through the induction pipe would really do no harm. At the same time, when one sees water dropping from the carbureter, it is only natural to assume at the first glance that it is caused by water in the gasolene. However, we give the hint for what it is worth; as if the idea is once obtained that there is water in the gasolene, a lot of trouble will be taken for nothing. There is also a certain amount of condensation in the induction pipe, and beads of moisture may be noticed in it from this cause.

Flooding Carbureters.

When persistent flooding of carbureters occurs, it is generally due to one of two things: Failure of the needle valve to seat properly, which can, of course, be overcome by grinding in the valve, or to a punctured float, which allows a small quantity of gasolene to enter, and thus upset the balance and allow the gasolene level to rise higher than it should do, and consequently to flood. This can be easily discovered by shaking the float, when the liquid can be heard inside. To find the hole and get the gasolene out is somewhat difficult, but the following is the simplest way: The float should be put into very hot water and held beneath the surface. The heat causes the gasolene to gasify and be driven out through the small hole, when the issuing bubbles will make it clear where the hole is. The float should be thoroughly cleared of gasolene, and the hole stopped up with solder. In doing this, it is a mistake to put as little solder as possible on to the hole, but the job should be done thoroughly and be cleaned afterwards with fine emery paper. Of course, care must be taken not to allow too much solder to remain on, so as to upset the balance of the float, and not to allow the solder to get into the float. Silver solder is better than soft solder for this purpose. If after the hole has been closed a slight leakage follows which it is impossible to locate, a good method of preventing further trouble is to give the whole float a good coating of nickel by electroplating it. This closes up the small porosities better than any solder will do.

With carbureters of the Longuemare type, with a weighted needle, flooding is sometimes due to a third cause. The weight occasionally bears on the seating, and does not allow



The Schebler Carbureter—Model F—Section.

A Compensating air valve
B Float chamber
C Mixing chamber
D Spraying nozzle
E Needle valve
F Float
G Reversible union
H Float valve
I Needle valve adjusting screw
J Float lever
K Throttle
L Needle valve retainer
M Air valve adjusting screw
N Cork gasket
O Air valve spring
P Throttle lever
Q Needle valve lift lever
R Throttle stop
S Pivot screw
T Float valve cap
U Flushing pin
V Lock nut
W Needle valve hex connection
X Spring cam casting
Y Eccentric high speed adjustment
Z Air valve shutter lever
1 Air valve butter-fly disk
2 Spring
3 Lock screw
4 Cam spring
5 Lock nut for bowl
6 Air valve cap
7 Needle valve retaining spring
8 Needle valve spring
9 Constant air opening

the needle to seat properly. The result is that flooding occurs either continuously or intermittently when the motor is running, as then the vibration shakes the needle from its seat.

Warming the Carbureter.

A kink applied very successfully for starting the engine when the atmosphere is chilly is simply to fill an ordinary india-rubber hot-water bottle and apply it as far round the carbureter as possible, leaving it there for a sufficient period

to enable the carbureter itself to draw some heat and thus assist vaporization. Another method is to wrap around the carbureter some absorbent material, such as large size lamp wick, which can be carried for the purpose, and to pour over this hot water, repeated applications of which will raise the temperature of the carbureter even higher than will be obtained by the usual heating by a branch from the exhaust.

The Freezing of Carbureters.

"During a snap of frost," writes an enthusiastic automobilist, "we had an experience with one of our cars which may prove a warning to others. While the cooling water circulating system was in a sufficiently warm place to prevent its freezing up, yet it did not protect the carbureter from the effects of the frost. This particular carbureter has a hot water jacket around the mixing chamber, which is in close proximity to the float feed chamber. A single cock is provided to prevent the water circulating round the jacket when extra heat is not required, but it was impossible to drain the water from the jacket. The low position of the carbureter, and the lower temperature occasioned by the near presence of gasolene, were too much for the water around the carbureter, and it froze up. A natural consequence was that something had to go, and, fortunately, the weak spot was found at a plate soldered over a clearing hole in the water jacket. This gave way, and when the thaw came we had a fountain display beneath our engine bonnet. As a protection against similar occurrences, we had an extra cock put into the circulation pipes on the other side of the carbureter, and a drain cock put into the lowest point."

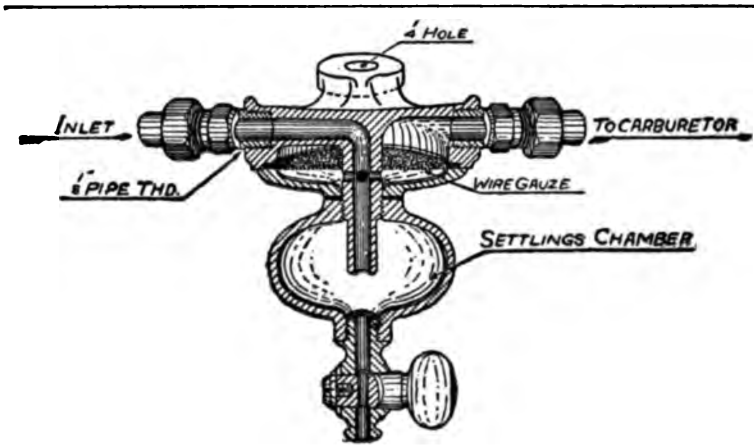
When the Jet is Blocked.

Few owners care to take down a carbureter by the roadside, especially as some carbureters appear to be constructed with the sole object of making it as difficult as possible to get at the jet. When the jet is blocked it is always well to try flooding before taking the trouble to pull the carbureter to pieces. Many automobilists know this little wrinkle, but

plenty do not. It is simply a matter of holding the float down or up, according to which way the gasolene is admitted, so that the full head of gasolene in the tank may come through to the jet. In nine cases out of ten it will free it—possibly only temporarily, but still enough to enable one to get along and to postpone the taking down of the jet till one gets home. When once the engine has been got going again one can keep a careful ear upon its running, and directly it shows signs of flagging, race it a bit, and race it with the extra air inlet (if such is provided) closed. This puts so strong a suction on the jet that it will often remove the obstruction, and that without stopping the car.

Choked Carbureters.

One of the most exasperating of minor troubles which can fall to the lot of the motorist is to have a partially choked



The Schebler Fuel Strainer—Cross Section.

gasolene jet in the carbureter. If the jet were wholly blocked up and the engine could not be run at all, one would naturally go to the carbureter (if not at once, directly after testing the ignition), and the cause of the trouble would be revealed. On the other hand, when there are particles of foreign matter floating about, they will keep more or less clear of the jet,

but they are never far away. You flood the carbureter and start up the engine, which runs merrily for a few revolutions, coughs, chokes, and stops. What has happened? Those free bits of dust which were merely agitated by the action of flooding the carbureter have by the constant suck exerted by the engine been drawn up into the jet and effectually blocked it. The engine being stopped, the bits fall away from the jet again, and so the process of numberless startings up of the engine is performed. Now, if the ignition be found in order, and the gasolene feed to the carbureter be clear, it is nearly always advisable to proceed to the jet and clear it out straight away. While the jet is out, run some gasolene through the jet orifice to wash away any particles which may be left behind. The jet being clear, it may be replaced and flooded, in order to ascertain that all is perfectly in order.

Attention to Automatic Carbureters.

Automatic carbureters, like many other good things, require keeping thoroughly up to the mark, otherwise they are apt to become a source of trouble. A great many of the automatic carbureters now in use have a sliding plunger or piston, the suction of the engine on the plunger causing a greater or less opening of extra air inlets. Now, when taking in air through these extra orifices, of course, whatever dust or other foreign matter is present in the air is taken in past the automatic piston, and, since moisture usually condenses about this part, the dust is there deposited. The effect of this is to cause the piston to stick or work erratically, this having a bad effect on the running of the engine, apart from increased gasolene consumption. Some automatic pistons are made so that they can be readily detached, so that in such a case all that it is necessary to do is to see that the piston is washed out pretty frequently, but in cases where such cannot be done it is a good plan to get a small syringe and wash the piston orifices thoroughly with a spray of gasolene, which does the job quite as well. Of course, in doing this, care must be taken that no naked lights are in the vicinity of the car-

bureter, nor until the gasolene vapor is thoroughly removed must a lighted match be thrown on the floor, otherwise a fire is certain to ensue.

Another frequent cause of trouble with automatic carbureters is that due to the spring losing its tension or in other ways getting out of adjustment. There is usually a small nut or pair of nuts fitted, which can be screwed up or down to alter the tension or pressure on the piston controlling spring, and sometimes such nuts are rather likely to shake loose and alter their position relative to the stem on which they are screwed, thus altering the spring tension. These should be examined from time to time to assure the user that they are in the correct position. When the spring becomes too weak, either a new spring must be fitted, or, as a temporary measure, the old spring can be removed and carefully stretched and then replaced, the adjustment being made by means of the nuts, as before mentioned.

Air Inlet Gauzes.

Assuming the gauze to take up three-quarters of the air inlet—which is usually the case—the area of the gauze should be made about four times as large as the actual air inlet.

This is provided for by supplying a funnel over the mouth of which the gauze is to be fixed. As an alternative, if the funnel cannot be fitted, the gauze should be made into a cone and slipped inside the pipe, as in this way the area of the gauze is made sufficiently large to allow the right quantity of air to pass through it.

Gauzes fitted to the air intake of any kind of carbureter should be frequently cleaned. Otherwise they rapidly choke up with oil and dust, the result being that insufficient air passes to the carbureter, which means that the suction on the jet is increased and more gasolene taken to the engine than should be the case, resulting in heavy consumption, boiling water, dirty engine, overheating, and loss of power.

It is often remarked that unless a gauze is fitted the carbureter will choke up. In such a case the fact is overlooked

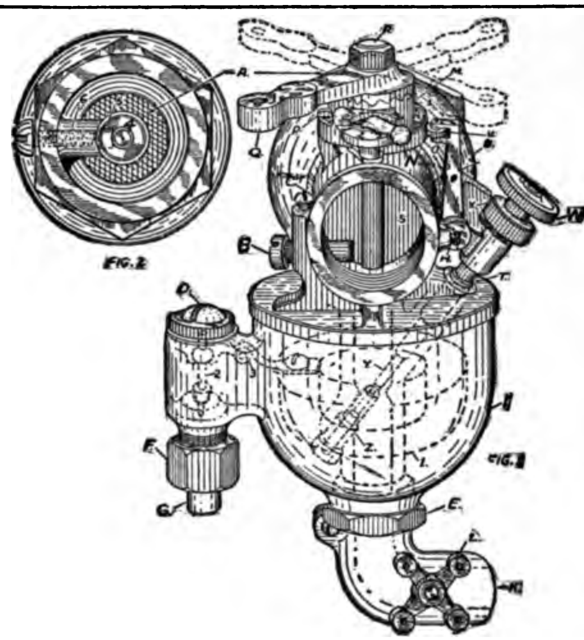
that chokage in a carbureter is due to chokage of the gasolene passage, and not to the air passages, and that dust getting into the carbureter by way of the air intake cannot get into the jet or gasolene passage. As a rule the only damage that dust can do is to get into the engine and pass out through the exhaust valve. While in the engine it can do little harm, though a deposit may be formed on the piston head by it. In one case it appeared to be carbon, in consequence of the bad quality of the lubricating oil. An analysis of the deposit, however, proved that it was caused almost wholly by dust-laden air which was drawn in through the air intake, which was not protected by gauze.

Obviously, the best thing to do is to fit a large gauze, which is detachable, and to keep it clean.

Gauze in the Induction Pipe.

From time to time many experiments have been made with gauze. Occasionally a wire gauze disk is put in the induction pipe, and gauze has been tried in the carbureter. The idea is that the mixture shall be more thoroughly atomized by passing through the fine meshes of the gauze. It may be safely said that the matter is one of experiment, and in some Longuemare carbureters it has been found a really distinct advantage. In this carbureter, the extra air inlet is below the jet, and the air holes are covered by a couple of segments, on the top of which is a perforated brass disk. This disk is just above the jet, and above or below the disk it is very easy to place three or four disks of gauze. Those who know the Longuemare carbureter will understand at once how easily this can be done. It has been found that the effect of the gauze was twofold. It has reduced gasolene consumption, and made it possible to run the engine at a considerably lower speed when desirable; this applies whether the engine is running light or driving the car. The improvement in running appears to be due to the more perfect atomization of the mixture, as the whole of the gasolene and all the additional air have to pass through the gauzes. There

is also a sort of wick effect, as the three or four thicknesses of gauze make a pad immediately above the jet, which is



The Schebler Carbureter—Model H—Section.

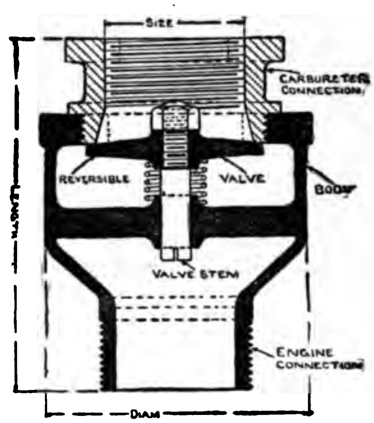
A Compensating air valve complete (4 pcs.)
B Low speed adjusting screw
C Low speed lockscrew
D Float valve cap
E Float chamber lock nut
F Reversible union
G Reversible union nipple
H Lift lever shaft retainer
I Float chamber
J Mixing chamber
K Constant air opening connection
L Butterfly valve starting lever
M Spring cam casting
N Eccentric high speed adjustment
O Cam spring
P Throttle stop
Q Adjus'ble throttle lever casting
R Throttle valve stem
S Throttle valve butterfly disk
T Needle valve retainer
U Needle valve lift lever
V Cam roller
W Needle valve adjusting screw
X Needle valve adjustment retainer
Y Needle valve
1 Float
2 Float valve
3 Float valve lever
4 Air valve adjusting screw
5 Leather friction disk
6 Friction spring

always saturated with gasolene, and seems to afford a small reserve, which results in a better pick-up after slowing on the

throttle. It is obvious that the gauze must have a wire-drawing effect, and thereby put a certain amount of negative work upon the engine, but this negative effect is more than nullified by the superior atomization, so that the maximum power and speed of the engine is not reduced in any way, and the advantages of smoother running at low speeds and a quicker pick-up are gained.

The Breeze Carbureter.

The Breeze carbureter is a good example of the modern carbureter, and is therefore fully illustrated herewith. The manufacturers claim that this carbureter is equally adaptable to all engines and that, when adjustments are once properly



The Breeze Carbureter—Check Valve.

made, it will deliver the right kind of mixture to the engine at all speeds at which it will work without change of adjustment.

The special features are stated as follows:

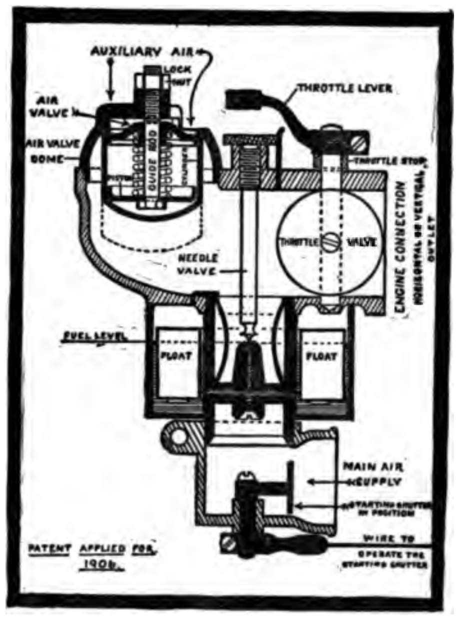
1. Simplicity: all adjustments are independent and when made, stay set.

2. Gasolene and air adjustments both placed on top of the carbureter, the gasolene valve having figures and graduations stamped on a dial head indicating its exact position.

3. Non-fluttering auxiliary air valve maintains an even addition of air to the mixture at high speeds.

4. Central draught for main air and gasolene spray prevents changing of fuel level on grades. The gasolene is always there.

5. Peculiar construction of the needle valve causes the breaking up of the fuel into the smallest particles possible, giving at the same time economy and power.



The Breeze Carbureter, Showing Main Air Supply and Strangling Tubes.

6. Choice of vertical or horizontal, or male or female connection to engine.

7. Carbureter easily detachable from flange of engine pipe connection.

8. Spun brass float, obviating all need of adjusting fuel level, which is a frequent trouble with a cork float.

9. Interchangeable main air tubes giving a wide range of

main air supply and still maintaining the correct cone-shaped air passage.

10. Simple and easily detached hot air attachment.

Principle—The Breeze carbureter consists of a fuel chamber provided with a float feed device to maintain the fuel level always at a point just below the spray nozzle, which is connected by a cross tube to the fuel chamber; when air is sucked through the conical-shaped main air tube by the engine, a proportion of gasolene is drawn up into the engine with it. This proportion is determined by the adjustment of the needle valve. As the suction increases when the throttle is opened or the engine runs faster, the proportion of gasolene taken up is greater than it should be, so the auxiliary air valve is provided and arranged to open against a spring and admit pure air according to the increased suction of the engine. By proper adjustment of this valve spring, it is claimed, the carbureter can be made to furnish a uniform mixture to any engine. A valve or throttle is provided to govern the amount of mixed gas delivered to the engine.

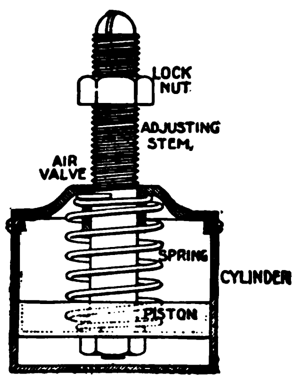
The fineness of the mixture of gasolene and air determines the economy and also the maximum power obtainable from a given size carbureter. A certain minimum of suction is necessary on low engine speeds; and adjustment to make different model engines obtain this is provided by using different sized strangling tubes for the air intake around the spray nozzle.

Auxiliary Air Valve—An auxiliary air valve is provided to furnish the engine with more pure air on medium and high speeds. On low speeds this valve must stay closed and the Venturi tube around the spray nozzle, which the Breeze people have used since 1904, is small enough to keep the suction sufficient to give a good mixture and is automatic within a moderate range of low speeds, but on medium and high speeds the mixture gets too rich in fuel. Fuel is necessary for power, but must have air in the right proportion to burn with it.

The auxiliary air valve is held to its seat by a spring, and the engine suction on medium and high speeds opens it to that

distance which the spring tension permits. This adjustment properly made, the suction of the engine regulates the mixture automatically by pulling the valve open to the proper distance.

To adjust the valve, loosen the air valve adjusting lock nut, turn the slotted stem to the left to stiffen the spring and decrease the air, to the right to weaken it and give more air. Be careful in weakening the spring and giving more air not to weaken it so much that the valve does not seat. Air must



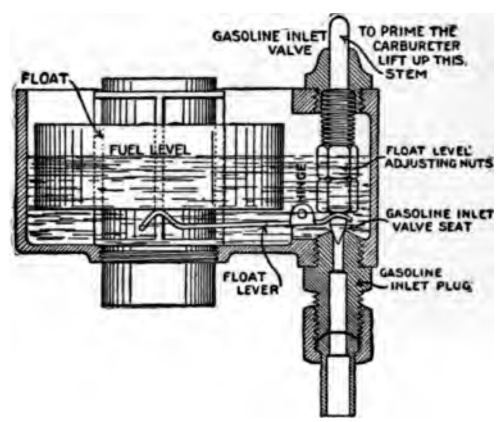
The Breeze Carbureter—Auxiliary Air Valve.

not get in on low speeds or starting will be almost impossible. Lock the adjustment securely.

This device is simple and needs no attention unless both oil and sand get on it at the same time, in which case it will stick and must be cleaned out. Leave all parts dry. Do not oil it. If this happens it would be advisable, for the good of the engine, to protect the carbureter by an apron. The amount of sand required to spoil the working of the air valve would be very bad for the engine if allowed to get to it. No trouble is experienced with the valve under the hood of a touring car. When a carbureter is used where water or dirt are thrown on it, the manufacturers furnish a gauze cage to cover and protect it.

Float Feed Mechanism—When the fuel is at the proper level

the gasolene inlet valve is held down to its seat by its own weight and the spring closes the supply, the float being clear of the float lever. As soon as the level drops the float drops with it, and resting its weight on the long end of the float lever pushes it down and lifts the short end which lifts the gasolene inlet valve and admits more fuel till the float rises clear of the lever again. To raise the fuel level adjust the nuts on the gasolene inlet valve nearer the point of the valve; to lower it, set them further away. Lock them tight after the adjustment is made. The distance from the bottom edge of the adjusting nut to the point of the gasolene inlet valve averages



The Breeze Carbureter—Float Feed Mechanism.

about 5-16 of an inch on a properly adjusted carbureter. Don't change the tension of the spring. The fuel level must be properly adjusted on any float feed carbureter. The correct point is usually about 1-16 inch below the tip of the spray nozzle. For an engine with short inlet pipe of large diameter the level may be set a little lower. Keep the level as low as possible. A high fuel level wastes fuel and causes an engine to heat up.

Adjustment of the Breeze Carbureter—Adjustments can always be best made with the muffler cut out or better still the exhaust pipes taken off so that the exhaust from each cylinder

may be observed. If the ignition is right and the compression and valve setting the same on all cylinders the exhausts should all be the same color. The blue flame exhaust is not the best for power, the mixture is too rich. The purple flame is the correct color. A yellow color shows too weak a mixture; black smoke, too much fuel. Too much oil makes the color red.

From three-quarters of a turn to a turn and a quarter is the usual opening of the needle valve required. Screwed all the way down it is closed. To open it turn backward. The correct position can only be determined by experiment. With

Gauze Cage for Exposed Carbureters.

the throttle and spark stationary, the correct position for the needle valve is that at which the engine runs fastest.

Set the needle valve first for low speeds with the throttle nearly closed and the spark on center. Then advance the spark and open the throttle and adjust for high speeds by tightening or loosening the tension of the auxiliary air valve spring.

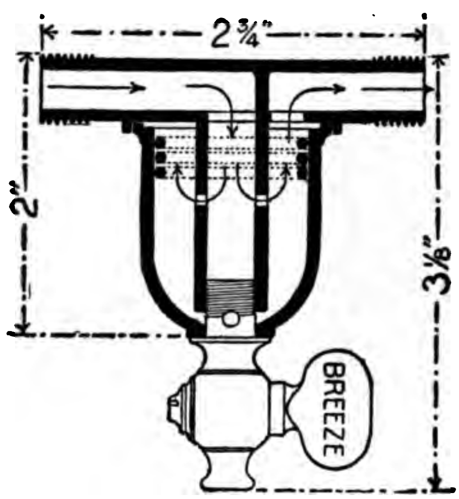
Backfiring is caused by too weak an air-valve spring, dirt in the carbureter, or an insufficient flow to the carbureter. If the auxiliary air valve spring has to be weak, a small strangling tube may be used around the spray nozzle and a large one where the auxiliary air valve spring has to be very strong. A particularly strong spring has to be used with engines of the valve-in-the-head and "T" head types.

Carbureter Troubles.

The following remarks, for which we are indebted to "Carbureters and Engine Troubles," published by the Breeze Carbureter Company, apply to almost all float feed carbureters.

Air valve springs shorten slightly after long use, and adjustment is provided to take up the tension. Imported steel wire for springs, copper plated to prevent rust, stand up longer than the cheap brass wire frequently used.

Dirt getting into the spray nozzle causes backfiring in the



The Breeze Fuel Strainer.

carbureter, and while the engine runs very fast and free on starting it will stop when the clutch is thrown in. The dirt can generally be got rid of by opening the gasolene adjustment a full turn while the engine is running; it is sucked clear through the spray nozzle. Sometimes a larger piece of dirt gets in and acts as a valve, stopping up the nozzle when the throttle is opened. The only plan in this case is to take off the base and clean out the fuel passages. Don't go to this trouble till you are sure that your battery is not weak. The symptoms are often the same.

Irregular running of the engine may be caused by dirt in

the carbureter, sticking float lever or fuel valve, and very often by a nearly broken battery wire, dirty commutator or sticking coil trembler. Speeding up and slowing down under load are generally caused by too small a fuel pipe, insufficient head to the fuel, or dirt or water.

Overheating of the engine may be caused by many things, as insufficient water circulation, improper timing or insufficient lift to exhaust valves. Either too weak or too rich a mixture burns slowly and gives up a larger proportion of heat to the cylinder head and wall than a perfect mixture does. A poor spray overheats, so does poor oil.

Often when a new carbureter is fitted to a car that has been used the complaint is made that as soon as the throttle is opened the engine pounds and knocks and that the symptoms are worse than before. Very likely. The new carbureter probably gives more gas and power than the old one, and of course when combustion chambers and piston heads are carbonized from poor oil or bad mixture, the more gas you put in the cylinder the worse the knock. Take off the cylinder heads and soak them over night in kerosene, clean them thoroughly, and piston heads too, and don't neglect the valve passages. It is not so much the even deposit as the little lumps that stick up that cause the trouble.

Commutators or unevenly timed tremblers on coils sometimes cause trouble. The explosions must take place in each cylinder when the piston is in the same position. If any cylinder is timed too early there will be loss of power, knocking, overheating and possibly a broken crankshaft and always a quicker wearing out of wrist pin and crank pin bearings. A wabbly commutator makes the same trouble.

Missing in one cylinder may be caused by that cylinder having a leak around the valve or valve cage seats, by the inlet valve opening too much and not closing as quickly as the others, or by a valve not seating at all; or, by that cylinder being carbonized. These things cause the engine to take a different mixture. If the cylinders are right the same carbureter adjustment will suit all.

Flooding—Suppose when you turn on the gasolene or stop your engine there is a persistent dropping of gasolene from the bottom of the carbureter. It must be stopped, fuel is being wasted and the mixture spoiled on low speeds.

Don't start in to change the fuel level till you are absolutely sure it is wrong. Flooding when caused by dirt under the fuel valve can often be stopped by lifting the fuel inlet valve and letting the dirt flush through. If this does not stop it the level is most likely too high.

Before readjusting the float level you might take off the base and take out the float and shake it and listen for liquid inside; a leak, though very rare, is possible, and will permit gasolene to get inside and lessen the float's buoyancy. Write or wire for a new one and then return the leaky one for repairs. A temporary repair can often be effected by drying out the gasolene and painting a little shellac over the leak. Don't mistake loose solder in the float for gasolene.

Having tested these points if the trouble is not there, the fuel level is too high and must be adjusted. Shut off the fuel every time you put away a car. It is safest, because there is no float feed mechanism that can always be trusted absolutely, and besides this the lighter part of the fuel keeps evaporating till the bowl of the carbureter is full of too heavy a liquid to make starting next morning as easy as it might be. Always have two shut-off cocks in your gasolene line, one at the carbureter or where you can get at it easily, and the other close to the tank, in case the pipe breaks. Either may save the car some day.

Carbureter Cautions.

Don't try and start with the throttle entirely closed.

Gasolene valves have been known to jar shut.

Remember that "Carbureter knock" may be found in a loose fly-wheel, in loose electrical connections or commutators that ground sometimes in the wrong place.

Don't adjust the carbureter as soon as the engine works badly. There are such things as clogged feed pipes, poor ignition, and exhaust valves that don't seat properly.

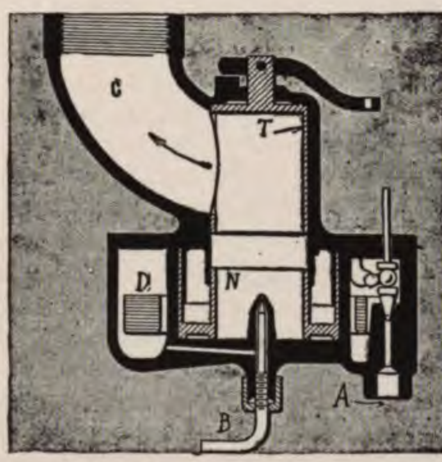
Flooding seldom means readjustment of float feed mechanism. Usually there is dirt under the gasolene valve seat or, very rarely, a leaky float.

Don't forget that automatic inlet valves must have a very short lift, and when the engine has more than one cylinder, the springs in these valves must be of an even tension. If these springs are weak or have too much lift, part of the gas will be blown backwards through the carbureter in the compression stroke.

Don't monkey with any carbureter till you have read the maker's book. You may know more about it than he, but you might as well get his ideas on the subject.

The Duplex Carbureter.

The Duplex carbureter, illustrated herewith, deserves attention because of its simplicity, freedom from springs of any



SECTION OF DUPLEX CARBURETER

nature, and compactness of design. Its only adjustment is with the gasolene needle valve B, which can be accomplished from the under side of the carbureter. In design the Duplex carbureter is conventional with its gasolene intake A, regulated by a needle valve, controlled by the concentric float D.

T is the revolving vertical cylinder throttle and C the passageway to the motor. This carbureter is without any auxiliary air intake and the only air intake is regulated by a solid sleeve N which is claimed not to impose any drag whatever on the engine. The action of this sleeve is governed by vacuum and specific gravity. The sleeve is protected by an air cushion in which the degree of vacuum depends entirely upon the action of the engine. The rise and fall of this sleeve N is entirely automatic. A glance at the carbureter will show that no priming arrangements are provided for, the maker claiming the carbureter to be capable of quick and easy action, which facilitates starting in cold weather. The throttle lever seen on the top is attached by a binding screw which permits of adjustment to conveniently attach the lead to the steering wheel in any direction, thereby eliminating complicated connections. The exit pipe C is of such design as to permit of the carbureter being used on vertical or horizontal motor.—Motor Age.

The Locomobile Carbureter.

The Locomobile carbureter is shown here in diagram and a photographic illustration appears on another page. It is described as follows:

"Gravity feed is employed, the carbureter being placed sufficiently low so that the bottom of the fuel tank is always at a considerable elevation above it; this insures a flow of gasolene, as the head is ample and the force of gravity never fails to operate. Further than this, the bottom of the gasolene tank is not level but slopes towards the point of discharge, so that the machine can be operated over the hilliest of country roads until every drop of fuel is drawn from the tank, the motor running properly until the fuel is entirely consumed. The piping from the tank to the carbureter is of substantial character, with a valve interposed to cut off the supply of fuel when desired. A settling chamber is placed at the bottom of the float chamber so that any impurities may settle to the bottom and be drawn off through a pet-cock. At the top of this settling chamber is placed a horizontal wire gauze so that

impurities cannot pass up into the float chamber. This is an extremely interesting feature of the Locomobile carbureter and will appeal to anyone. The settling chamber and the wire gauze can be removed when desired and cleaned if necessary.

"The Locomobile carbureter is of exclusive design and manufacture and is of the simplest possible character, operating in a reliable and satisfactory manner, with practically no attention. The float is of spun copper and is carefully adjusted, the adjustment being marked on the top of the carbureter, so that in case it is necessary to readjust it, it can be done without returning the apparatus to the factory.

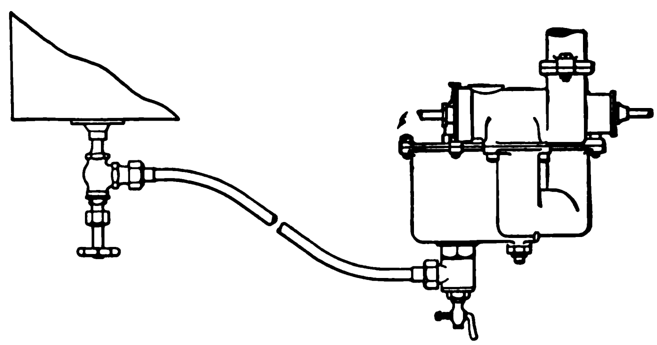


Diagram of Locomobile Carbureter and Gravity Fuel Feed.

"The spray nozzle, or atomizer nozzle, consists of a hollow tube, pointed at the upper end; it screws into the bottom of the carbureter casting until the lower part comes up against a shoulder. Thus the nozzle may be removed instantly and cleaned, and when put back the adjustment is not disturbed.

"The throttle is of the balanced piston type, desirable because the suction from the pistons of the motor does not cause it to bind against the walls of the throttle chamber and cause friction.

"The automatic air valve is used, of course, to supply the additional air as the throttle is opened and more gas is fed to the motor. The Locomobile valve consists of a hollow, cone-shaped spring, the coils of which separate as the motor speeds up, thus feeding more air to the mixture and keeping

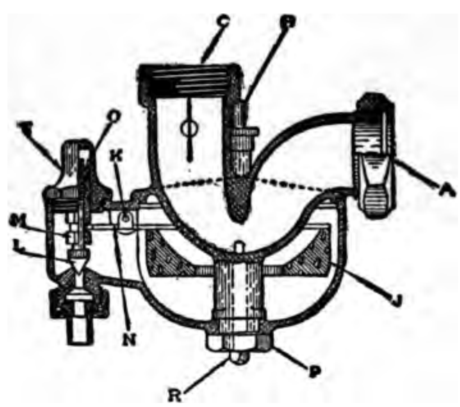
it uniform in quality. This forms an extremely simple and reliable arrangement.

"The mixing chamber of the carbureter is supplied with two valves, one admitting hot air drawn from around the exhaust, and one for cold air; thus a full supply of hot air may be fed to the mixing chamber, or any desired mixture of hot and cold air which will give the best results for conditions as they may exist at the time. The adjustment as made at the factory is correct for ordinary atmospheric conditions and should rarely be altered."

CARBURETER ADJUSTMENTS.

The Holley Carbureter.

In the illustration of the Holley carbureter the adjustable gasolene needle is shown (L). The air enters at A and passes



The Holley Carbureter, Model "W."

down and up through a U-shaped mixing tube. The gasolene enters from the float chamber by an orifice controlled by the adjustable needle. The normal gasolene level is 3/32 inch above the bottom of the U-shaped passage, so that a puddle is formed. Here the air passage is restricted, increasing the velocity of the stream. As the motor speed increases. the puddle is gradually swept away and its area diminished, preventing the formation of an over-rich mixture. At the

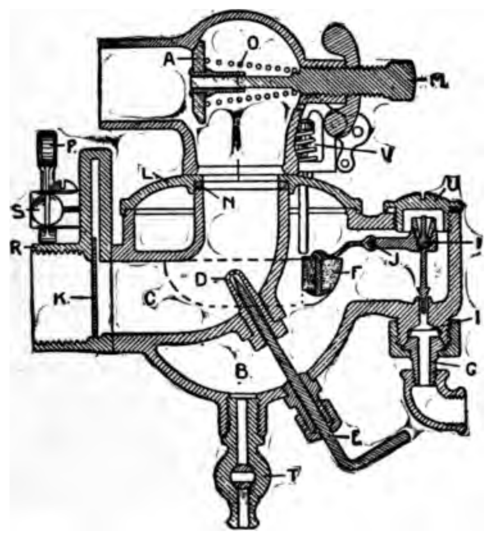
highest speeds the puddle is wiped out and an ordinary spray takes its place. An overflow device prevents flooding.

In operation the gasolene needle is adjusted to a point where the motor runs best, with throttle wide open and spark about center. Next close the throttle to where the motor runs slow enough to suit. If the motor will not run slow, it indicates lack of gasolene because of too low level. If motor runs slow enough with throttle partly closed, but misses upon opening throttle, it indicates too high a gasolene level. To change the level remove the gasolene inlet needle guide cap T and take out the gasolene inlet needle. Hold the weight M by its flat sides (so as not to mar it and cause it to stick) and loosen the taper locknut O. Then by screwing the needle into the weight M the gasolene level is raised in the float chamber; by unscrewing these parts, the level is lowered. One turn of the needle L in the weight M changes the gasolene level about 3/32 inch; one half turn about half, etc. When level is where desired tighten locknut O. Normal level should show puddle about 3/32 inch deep when motor is not running. Conditions may demand this to be altered slightly. R is a sediment plug and has nothing to do with adjustment.

The Schebler Carbureter.

In the Schebler carbureter, of which we illustrate several models, when the motor is running at its minimum speed, the air is drawn through an aperture of fixed dimensions. As the speed is increased, and consequently the flow of gasolene becomes greater, more air is needed and this additional supply is furnished by the compensating air valve A (see illustration of Schebler Model D), which opens more and more as the speed of the engine increases. The compensating air valve, when once adjusted, admits a regulated supply of air in accordance with the degree of vacuum produced by the piston of the motor. In adjusting, the needle valve E should be first closed, and then opened about from five-eighths to three-quarters of a turn. Retard the spark, open the throttle P about one-fourth, so as to equalize the fixed air open-

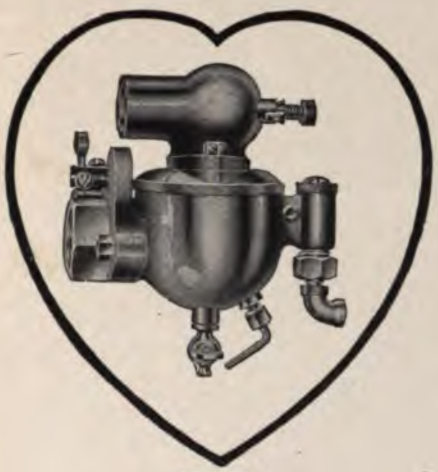
ing below the compensating air valve A. Start the motor and adjust the needle valve E until the motor runs smoothly and without back firing or missing. Now open the throttle P wide, keeping the spark retarded, and by turning the air valve adjusting screw M increase or weaken the tension on the



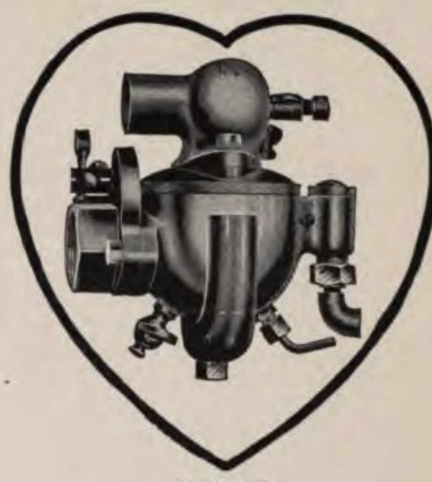
The Schebler Carbureter—Model D—Section.

A Compensating air valve	L Float chamber cover
B Float chamber	M Air valve adjusting screw
C Mixing chamber	N Cork gasket
D Spraying nozzle	O Air valve spring
E Needle valve	P Throttle lever
F Float	R Pipe connection
G Reversible union	S Throttle stop
H Float valve	T Drain cock
I Float connection	U Float valve cap
J Float hinge	V Flushing pin
K Throttle	

air valve spring O until the proper mixture is obtained. If the mixture is too rich, the tension of the spring O should be weakened, permitting more air to enter the carbureter; should the mixture be too weak, the tension of the spring should be increased.



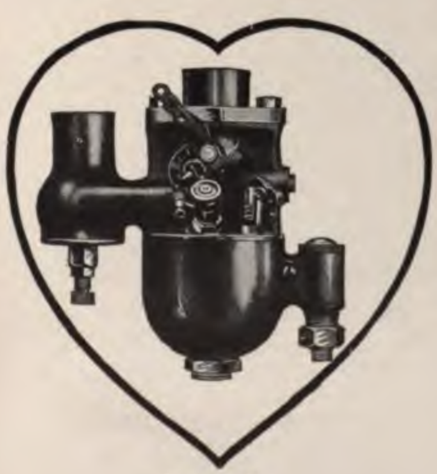
Model D.



Model E.

Schebler Carbureters.

(Wheeler & Schebler, Indianapolis).



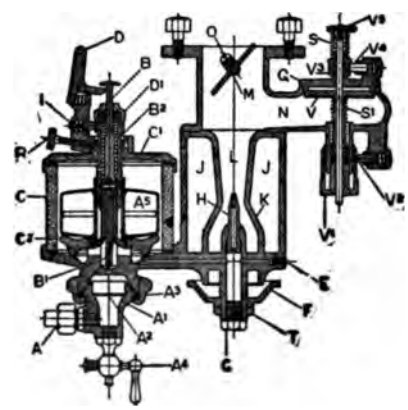
Model F.

Model H.

Schebler carbureters are made of brass, but aluminum is furnished on special orders. The bowl design combines compactness with practicability, serving for reservoir as well as having the float chamber embodied therein. The float is made of cork, heavily shellaced and hinged as shown in the sectional view, letter J. The size of the gasolene valve is much larger than ordinarily used. Gasolene is supplied through a reversible union which permits the feed pipe to run in any direction desired.

The Stromberg Carbureters.

Many well-known machines are fitted with the Stromberg type carbureters, of which we illustrate two examples in section and also by photographic reproductions. The details of construction are plainly indicated in a full-page illustration.



Stromberg Carbureter—Type A—Section.

The following are the methods of adjusting these carbureters:

How to Adjust Stromberg Type A.—After the carbureter is installed turn on the gasolene, and note if the level of the gasolene in the float chamber is opposite the mark or line cut on the outside of water jacket opposite float chamber. By turning the adjusting nut D-1 up or down you can raise or lower the gasolene level so that it will be opposite the

line. Do this before starting the engine. Next see that the valve V seats lightly by tapping the nut V-5 lightly with the forefinger. If it does not seat, turn up adjusting lock V-1, or if too tight, turn down V-1. See that adjusting locknut V-3 is turned down as low as possible. Next prime the motor by lifting the needle valve B until float chamber is filled. You will notice that gasolene drops into the adjustable air cup F. This cup should be adjusted in this manner: Turn up the air cup F until it is tight, then turn it down one or two turns, possibly three, according to the motor. On the average motor this will admit the proper amount of air which regulates the gasolene supply. If you are getting too much gasolene, turn the cup up, if too little, turn it down.

Next start the motor and adjust the low speed adjusting nut V-1 with both the throttle and the spark retarded. The spring S-1 is used to seat the valve V, and if the mixture is too rare and engine back fires, turn up nut V-1 until the motor runs smoothly. Next advance the spark and open the throttle gradually until it is wide open, and if the motor back fires, turn up the high speed adjusting nut V-3 one notch at a time until the motor runs smoothly without back firing. Remember that the valve spring S simply controls the valve V on open throttle or high speed, and should not be in contact with nut V-5 when motor is at rest. The seating of valve V is entirely controlled by spring S-1. There should be a space between the nut V-5 and spring S of about 1-32 inch and not over 1-8 inch, according to the motor.

In very hot weather shut the water off when the carbureter gets too hot. If the water is drawn from the radiator of the car, either to clean same or in laying car up for the winter, be sure and disconnect the water pipe connections to the water jacket on the carbureter at J-2, so that the water jacket will also be drained. It may be that in adjusting the nut V-3, which is called the high-speed adjusting nut, to stop motor back firing you will have to turn up nut V-1 one or two notches, but after doing so be sure to see that the motor runs smoothly on closed throttle.

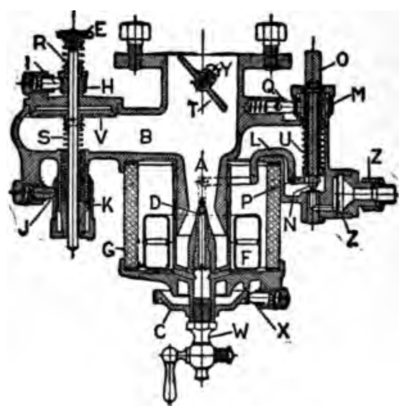
The motor uses just enough gasolene to keep it going on low speed, and as it increases in speed it takes automatically the quantity of gasolene which is necessary. The suction created by the motor draws air in through the fixed air opening between the adjustable air cup F and the bottom of the water jacket passes up through the mixing chamber L past the spraying nozzle H, and in passing sucks the gasolene out of the nozzle in a canopy-shaped spray. This mixture is then joined by the air coming through the valve V, which creates a perfect mixture. The more air that comes in through the adjustable air cup and the less through the valve the richer the mixture will be and vice versa, so do not have your spring S-1 too tight.

How to Find Proper Nozzle Size—If after you have adjusted the auxiliary air valve according to instructions, the mixture is still too rich, adjust valve V until it is off its seat, then adjust locknut V-3 down as far as it will go, and if the mixture is still too rich, it is conclusive proof that the nozzle in the carbureter is too large. If the motor misses on high speed on normal adjustments, tighten up on valve V by turning up the nut V-3 and nut V-1. If these springs are then too tight to get proper mixture, put in a smaller nozzle. To change the nozzle H, remove the plug G, then take out nozzle with an ordinary screwdriver.

How to Adjust Stromberg Type B—Type B differs from Type A in being made without the water jacket and is concentric, having the float chamber built around the mixing chamber.

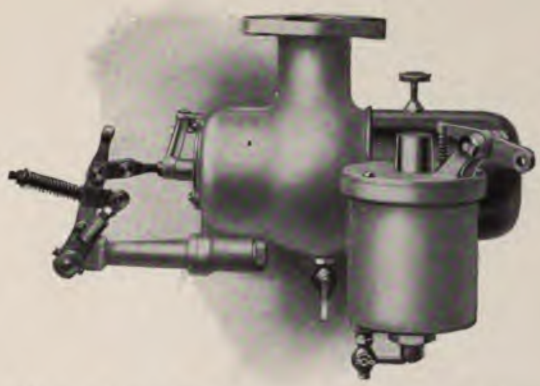
After the carbureter is installed turn on the gasolene, and note if the level of the gasolene in the float chamber is 15-16 inch from the rim on the bottom which holds the glass. By turning the adjusting nut M up or down you can raise or lower the gasolene level. See that the level is right before starting the engine. Next see that valve V seats lightly by tapping the nut E lightly with the forefinger. If it does not seat turn up adjusting nut K, or if too tight, turn down K. See that adjusting locknut H is turned down as low as pos-

sible. Next prime the motor by lifting needle valve O until float chamber is filled. You will notice that gasolene drops into the adjustable air cup C. This cup should be adjusted in this manner: Turn up the air cup C until it is tight, then turn it down two full turns. On the average motor this will admit the proper amount of air which regulates the gasolene supply. If you are getting too much gasolene, turn the cup up, if too little, turn it down. Next start the motor and adjust the low-speed adjusting nut K with both the throttle and the spark retarded. The spring S is used to seat the

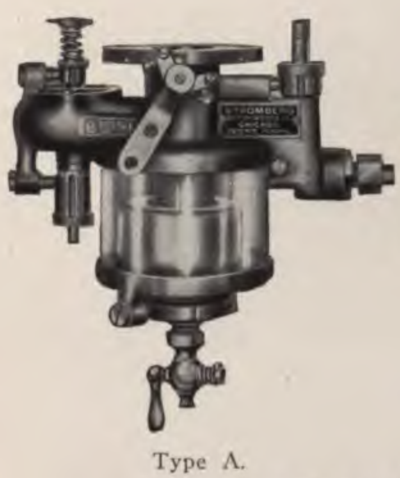


Stromberg Carbureter—Type B—Section.

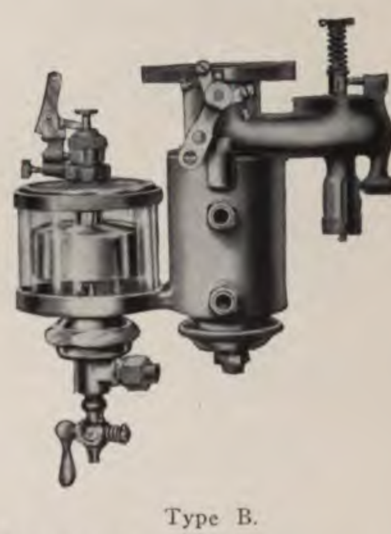
valve V, and if the mixture is too rare and engine back fires, turn up nut K until the motor runs smoothly. Next advance the spark and open the throttle gradually until it is wide open, and if the motor back fires, turn up the high-speed adjusting nut H one notch at a time until the motor runs without back firing. Remember that the valve spring R simply controls the valve V on open throttle or high speed, and should not be in contact with nut E when motor is at rest. The seating of valve V is entirely controlled by spring S. There should be a space between the nut E and spring R of about 1-32 inch and not over 1-8 inch according to the motor. It may be that in adjusting the nut H, which is called the high-speed ad-



The De Luxe Carbureter—An Exclusive Design.



Type A.



Type B.

Stromberg Carbureters.

justing nut, to stop motor back firing you will have to turn up nut K one or two notches, but after doing this be sure to see that the motor runs smoothly on closed throttle.

The motor uses just enough gasolene to keep it going on low speed, and as it increases in speed it takes automatically the quantity of gasolene which is necessary. The suction created by the motor draws air in through the fixed air opening between the adjustable air cup C, and the bottom of the gasolene chamber, passes up through the mixing chamber A past the spraying nozzle D, and in passing sucks the gasolene out of the nozzle in a canopy-shaped spray. This mixture is then joined by the air coming through the valve V, which produces a perfect mixture. The more air that comes in through the adjustable air cup, and the less through the valve the richer the mixture will be and vice versa, so do not have your spring S too tight. To change the nozzle D, remove the drain cock, then take out nozzle with screwdriver.

Carbureter, Alcohol—Carbureters for the use of denatured alcohol instead of gasolene in internal combustion engines are now successfully in operation. Experiments have also been made in the use of alcohol with acetylene. In this case the alcohol mixture is passed through a wire gauze containing calcium carbide and the water contained in the mixture acts upon the carbide and produces acetylene gas. Another type of alchohol carbureter is used with alcohol and gasolene, the engine being started with gasolene and running with alcohol as soon as the carbureter is sufficiently heated. Heat is invariably required for the complete vaporization of alcohol.

Carbureter Flooded—See under Carbureter.

Carburization—Same as Carburation, which see.

Carburize—To cause to unite with carbon or a hydrocarbon.

Cardan Axle—A universally jointed axle. See Axles.

Cardan Joint—A universal joint.

Cardan Shaft—A shaft having a special form of universal joint at both ends. See Shafts.

Care and Management—Private Housing—The private car house or garage should, if possible, be constructed of brick, stone or cement, though where cost is a prime consideration, very serviceable wooden and corrugated iron houses can be built. The house should be large enough to provide a space of at least four feet all round the car.

There should be large doors at each end of the house if space permits, so that the car may be run in one way and out the other. This will save a lot of time and trouble in reversing.

The floor should be of concrete, and care should be taken to avoid nooks and crannies, into which small parts can run and hide, if accidentally dropped. In the middle of the floor a pit should be dug. This should measure about 3 ft. 6 in. wide, 4 ft. deep, and 6 ft. or more long, according to the size of the car. Steps should lead down into it at each end, and a strong cover must be provided. The edge of the pit should have a projecting ridge to prevent the wheels of the car being accidentally moved over the pit, and also to prevent other things running into it. The pit, as well as the floor of the house, should be drained.

Light and Warmth.

Light is best admitted through windows in the roof, and these should be made to open and close, or other ample means of ventilation should be provided. If a current of electricity can be laid on to the garage, it will be found a great advantage in several ways. In the first place it affords a very convenient and safe means of lighting at night. Besides hand-lights that can be carried about, a number of fixed sockets for the electric lamps should be provided on the walls, and also in the pit. The electric current will also be useful in charging the batteries, especially if the car is an electric one. Naked lights should never be used about a motor car, when it is confined in a building. Of course, we are here speaking particularly of gasolene cars. Several buckets of sand, and some fire extinguishers should be placed about the house ready to be thrown on and stifle any fire that may begin. As already mentioned, water should not be thrown on burning oil or spirit.

A good supply of water should be laid on for cleaning purposes, and the soft rainwater falling on the roof should be collected in a covered tank, as soft water should always be used in the radiator. The water should be drawn off as clear as possible, and passed through a fine strainer into the radiator.

The warming of the house requires careful attention. It is not advisable to use a coal fire or oilstove inside the house on account of the flame. A very high temperature is not desirable; provided it is well above freezing, that is enough, though it is always safest to run off the circulating water, in case the heating apparatus break down. So far as the tires are concerned, the atmosphere of the house should be neither too hot nor too dry; nor, for that matter, too light.

A workbench should be erected near one corner of the house, and if it can be supplemented by a small lathe so much the better. If the car is provided with a detachable top for the body, a pulley should be hung from the middle of the roof, so that the top may be manipulated easily, and suspended clear when out of use.

Cleaning.

On returning from a dirty run the mud may be washed off the car by carefully turning the hose on it. The painted work may be afterward dried with a soft clean sponge, and be polished with a leather in the usual way. In using the hose, care should be taken to keep the water and grit out of the bearings and other working parts as much as possible. The tires should be wiped clean and dried. See that they are well inflated, and that no water gets in to rust the rims and rot the canvas. The exterior of the engine, gear, etc., may best be cleaned by a good-sized paint brush dipped in kerosene. If the leathers of the clutch, brakes or pump get too greasy, they may be cleansed by washing with waste gasolene. The clutch leather should not be allowed to get dry; on the contrary, it should be kept moist with special oil, evenly applied, and preferably allowed to soak in over night.

It is worth while giving the chains of chain-driven cars a good deal more attention than they generally receive. They

should be taken off occasionally and thoroughly cleansed in a bath of kerosene. Then they should be hung up to drain, and subsequently be dipped in a bath of melted tallow, which may contain a fair proportion of graphite. The tallow should be no hotter than is required to keep it liquid. After the chains have been stirred about in the tallow, so as to work it into the joints, they should be wiped, to remove the surplus grease, and allowed to cool. It is a good plan to keep two sets of chains, so that while one set is in use, plenty of time will be available for treating the other.

The muffler should be cleaned out occasionally to prevent the deposits therein accumulating to such an extent as to choke the passages, and so put back pressure on the motor.

Care of the Hands.

While on the subject of cleaning it may be as well to give here one or two hints as to cleaning the hands. Before starting to do anything to a motor car, it is a good plan to fill the nails and the crevices around the same with soap, and the fingers also may be rubbed over with the same material. This prevents the dirt securing positions from which it is most difficult to dislodge it. A great deal of the dirt that does adhere may be removed by rinsing the hands in kerosene or stale gasolene. To rub the hands in vaseline and put a few drops of ammonia into the hot washing water is a useful plan. Many have also found soft soap, pumicestone soap, and some of the advertised preparations useful for cleaning the hands. Gasolene, even if stale, comes in handy for removing grease spots from the clothes. A piece of flannel should be moistened with the gasolene, and a ring described with it round the spot, to prevent the latter spreading. Then a second application of the liquid should be made, first holding the moistened flannel on the spot for a few moments and then rubbing it vigorously. The odor very quickly passes off.

Lubricating.

All the rotating and rubbing surfaces on the motor require lubrication, except leather brake bands, leather pump tire, and

the stems of the inlet and exhaust valves. Besides the motor itself, the steering sockets, connections, worm and column bearings require attention; also the bearings of the road wheels, the transmission gearing and levers, the balance gear, and the starting apparatus. The pump and radiator fan bearings must not be overlooked. A new car requires more lubricating during the first 200 or 300 miles, while it is settling down, than it does afterwards. If the engine appears sluggish, it is sometimes due to lack of lubrication; a little extra oil will often help in hill-climbing. The dirty oil which accumulates in the crank case should be run off occasionally, and every few hundred miles the oil pipes and bearings should be cleansed out with kerosene, the engine run for half a minute or so in this way, and then the kerosene run off and full doses of proper lubricating oil administered. When using the kerosene, make sure that it runs through. If a pipe gets choked it should be blown clear, or a wire pushed through it.

While it is bad economy to stint the lubricating oil, it is a very common fault to use a great deal too much. This is not only wasteful, but tends to foul the valves, sparking plugs, and platinum contacts. Further, it has a prejudicial effect in creating a cloud of evil blue smoke. The driver should keep a look-out to see that he is not thus polluting the atmosphere and bringing motoring into evil repute. He should also be careful to close his lubricators when stopping, as otherwise the cloud will be apparent when restarting, even though the lubricators may be correctly adjusted for running.

Adjusting.

"Little and often" is an excellent motto in the care of motor cars, the "little" being a consequence of the "often." The great thing is to give the attention regularly. All working parts should be adjusted to move freely but without shake. This insures the highest efficiency and absence of noise. Spring washers are often useful in attaining these results where proper means are not provided for adjustment. All nuts used for positive gripping purposes should be secured by castle

locknuts, with split pins passing through a hole in the bolt and through the slots in the nut.

Adjustable Bearings.

As a rule, the owner will do well not to attempt the adjustment of plain and roller bearings. Ball bearings are comparatively easy to adjust, if provision is made for adjustment. At one end will be found a locknut, and on the same screw a cone. When the locknut is released the cone may be screwed along the spindle either into or out of the bearing. It should be screwed in until it will go no further without using force, then it should be unscrewed about half a turn. Now, if the locknut be retightened, it will probably be found that the bearing will work freely and without shake. It is better to have just a perceptible shake than to have a bearing too tight, and the final tightening of the locknut will usually tighten the bearing itself a little, owing to slackness in the screw threads.

A scrunching noise in a bearing should receive immediate attention, the bearing being taken apart in order to discover the cause. It may be found to be due merely to the presence of some grit, though that is bad enough. In this case a thorough cleansing of the bearing and lubrication will cure the trouble. If one of the balls is found to be broken, all the bits must be removed and a new ball inserted. But unless a new one of exactly the right size can be procured, it is best to run the bearing with the ball short for the time being; as, should the new ball be a shade too large, it will also certainly cause trouble. When the bearing is apart the cones and cups should be carefully examined for scores and cracks, as if these are found, the parts affected should be renewed at the earliest opportunity. In some cases, where the damage to the bearing parts is serious, it is best to remove the balls and let the bearing run on the plain surfaces as far as the nearest point available for repairs. If a wheel spindle has been cut into so as to weaken it materially, the load should be lightened as much as possible, or the run discontinued entirely, pending repairs.

A car should not be run with either the wheel bearings or

the steering crossbar joints very slack, as the wheels will wobble under these conditions, and the bearings and tires will get badly worn.

Brake Treatment.

The adjustment of the brakes is even more important than that of the bearings. They require treating according to their individual construction. Two points, however, should be borne in mind: First, that the pedal or hand lever should not be at the limit of its stroke, even when the brake is hard on; and second, that the braking surfaces should not rub anywhere when the brake is off.

Charging Batteries.

As there are now many stations where one can get batteries charged at a small expense, it seems hardly worth while troubling to do one's own charging if this involves putting in a plant for the purpose. But where a suitable source of electricity is available, it is a great thing to be able to keep the voltage well over 4; and where no charging station is at hand, it may be almost necessary to do the work oneself. And here the reader may be reminded that if he finds himself in a strange place where no one undertakes recharging, and where no wet cells are to be bought, dry batteries can often be purchased at the local hardware store; and one or two of these may be coupled in series with the expiring accumulators on the car, or a complete set may be secured to do the work alone. Failing this, you may have the good luck to get recharged from the generating plant of some large private installation.

The current for recharging may be obtained from a suitable dynamo (either directly or through an electric lighting system) or from a primary battery.

Recharging from a Strange Supply.

If the recharging is to be done from a dynamo constructed for the purpose, or from a specially-designed switchboard worked on the local electric lighting system, the job will be simple enough. But if you want to charge up from a strange

supply, the first thing to do is to inquire whether it is a continuous or an alternating current, and what is the voltage. We will suppose the current to be continuous, and of 110 volts.

The charging rate should be marked on the battery case. Usually it will not be over two ampères, but this may generally be exceeded by fifty per cent. if time is short. A safe charging rate may generally be found by dividing the ampère hourage of the battery by 10. A 16 c. p. (candle power) lamp will pass about half an ampère, and a 32 c. p. lamp will pass about one ampère, so a switch controlling four of the former or two of the latter lamps should be found. Two of the former or one of the latter will be better if the time can be af-

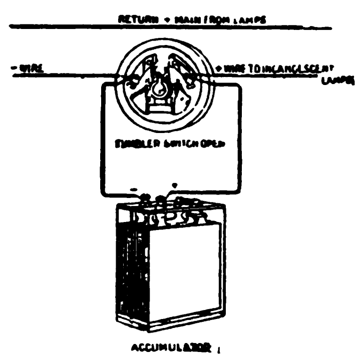


Fig. 1.—Charging from Ordinary Switch, Open.

forded, as slow charging at a low ampèrage is best for the battery, and conduces to long running. A six 16 c. p. or three 32 c. p. lamp switch may be used if one is in a hurry. The lamps are generally marked with their candle-power and can be disconnected from their sockets by simple twisting and withdrawing action.

The switch must be put into the off position (which will put the lamps out, so have another light handy), and must be kept in this position during the whole process. See Fig. 1. If the switch were closed it would short circuit the battery; and, besides wasting a lot of current, would damage the plates.

Pole Finding.

As charging is opposite to working, the positive pole of the charging apparatus must be coupled up to the positive pole of the accumulator, during charging. To find which pole is which in the switch, unscrew the cover, and connect separate wires to the terminals. Now take a slip of pole-finding paper, wet it thoroughly, and lay the free ends of the two wires on it, about half an inch apart. The paper will usually turn red around the end of the negative wire, but read the directions on the packet of papers as they do not all work alike.

If you have no pole-finding paper, drop a little vinegar into a glass of water, and hold the ends of the wires about ¼ in. apart in the water thus acidulated. Bubbles will be seen rising from the end of the negative wire. Bubbles may come from both wires, but if so, they will come faster from one (the negative) than from the other.

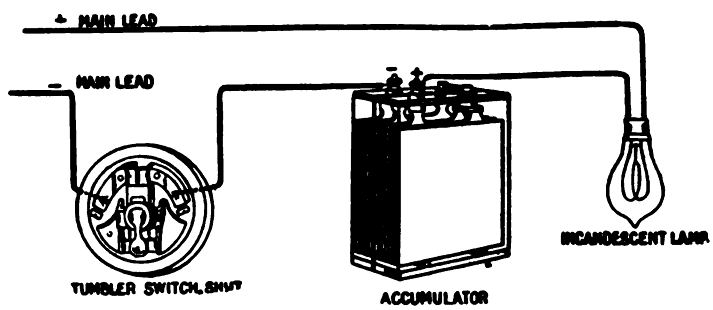


Fig. 2.—Charging from Ordinary Switch, Shut.

The two wires can now be coupled up to the terminals of similar polarity respectively on the battery; and as soon as the circuit is completed by so doing, the lamps will light up again.

Or one of the wires leading to the switch may be severed, and the ends thus made be connected to the terminals, positive to positive and negative to negative, as before. (Fig. 2.) This allows the switch to be used in the ordinary way; but, of course, the battery will not be charging when the switch is "off."

Instead of coupling up to a switch, one may employ an adapter. This is a fitting for attaching to a lamp socket in place of the lamp. The displaced lamp should be fitted into a socket comprised in the adapter, and the polarity of the wires having been ascertained, the positive wire is coupled to the positive terminal of the accumulator, and the negative to the negative, as before.

With a current of more than 110 volts, the number of 16 c. p. lamps should be increased, about in the proportion of one lamp to thirty volts. If the lighting system is worked on an alternating current, it will be necessary to employ a rectifier to transform the current into a continuous one. Some of the charging dynamos are made to be driven by water pressure from the house supply.

Charging from a Primary Battery.

But where neither electric lighting nor water is laid on to

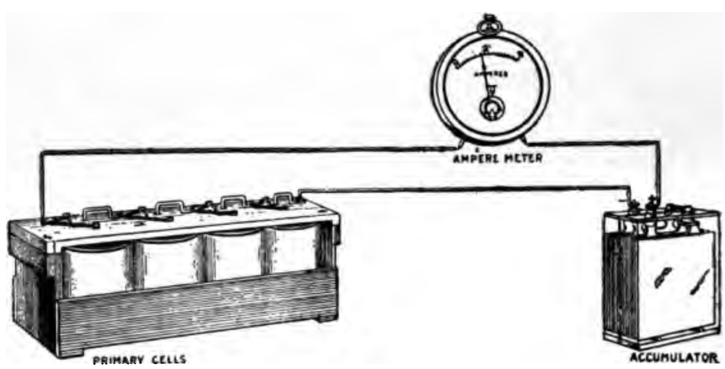


Fig. 3.—Charging from a Primary Battery.

the house, one can use a large primary battery. When employing this system an ammeter should be introduced into the circuit; and the zincs should be let down into the liquid just so far that the required number of ampères is shown on the meter. The zincs should be lowered from time to time to keep up the number of ampères. Instead of moving the zincs, a small resistance may be introduced into the circuit and adjusted as required. Some of these primary batteries should

be very carefully handled, as the liquids employed therein are highly corrosive. They require replenishing from time to time, and the zincs should be entirely withdrawn while the battery is not in use.

Whatever system of charging is adopted, the vent plugs should be removed from the accumulators, to allow free escape of the generated gases, during the process. The time occupied in charging naturally varies, but six hours to eight hours may be taken as an average. The battery should be disconnected soon after the electrolyte begins to bubble, and the voltmeter should then show a reading of at least 4.4. Sometimes it may show as much as 5.0, but the pressure will soon drop to an orthodox level when the accumulator is put to work. Wipe the case quite dry, vaseline the terminals, and replace the vent plugs before returning the battery to its position in the car.

Water Circulation.

A few hints may be given here on the subject of circulation. If the pump is driven by frictional contact with the flywheel, the spring should be adjusted so that it will just prevent slipping in the drive; greater tension will only have the effect of wearing out the bearings without any improved result. If it is suspected that the water is not circulating properly, one of the upper connections may be opened, when, if the water spurts out, it may be concluded that the circulation is in action. Some cars are now fitted with a manometer, which indicates the circulation of the water visibly. When one has become accustomed to a particular car, the condition of the circulation can be inferred from the temperatures of the inlet and outlet water pipes, as tested by the hand. If the water is not circulating satisfactorily the trouble will almost certainly arise from the pump. This should be taken to pieces and thoroughly cleaned, and any defect that may be found should be remedied as far as possible.

If the water is boiling, and one wishes to replace it with cold, the operation should be performed gradually. Do not simply run off the boiling water and then fill up with cold,

but make the change in easy stages. The advice given elsewhere to empty the circulating tank after each run in cold weather will bear repeating, but the risk of freezing may be reduced by mixing glycerine with the water in the proportion of one of the former to two or three of the latter (or some other anti-freezing mixture). Sometimes the pipes will become furred, and the cooling effect of the water thereby reduced, by reason both of the diminished capacity for water and the increased thickness of the containing walls. The fur may be dissolved by introducing a quantity of some strong alkali, such as caustic soda, into the cooling water. Two or three applications may be made until the water comes away practically clean.

If one of the pipes break, a temporary repair may be effected by slipping a length of rubber tubing over the broken ends, and binding tightly with wire. If the pipe has broken off close to one end, a reunion can sometimes be effected by tapering down the end of the pipe and somewhat enlarging the hole it ought to communicate with. The end of the pipe is then forced into the hole and tied in position, and the joint completed with red lead and insulating tape. This is a rather difficult repair, and should be superseded by a workshop job as soon as possible.

The Care of Tires.

One of the great advantages of pneumatic tires is that their strength of spring can be adjusted to the work they have to do, and they should be inflated to such a pressure that they will give only slightly when they rest under the weight of the car and passengers. So long as these conditions continue all is well. Occasional reinflation may be necessary. A speedy deflation demands instant attention. Pneumatic tires cost quite enough while doing their work, but to drive a car with a deflated tire is ruinous.

Directly a tire goes down the car should be stopped, and the cause ascertained. In case of doubt, the first thing to do is to reinflate, and then ascertain if the valve is leaking, by

placing a film of moisture over the orifice at the exposed end. If this is found to be the seat of the trouble, the valve should be tightened up or repaired, as the case may require. But unless the valve can be dealt with from the outside, the next step is to jack up the wheel and clean the outside of the tire cover. Then the tire must be completely deflated, when it may be opened.

Removing the Cover.

The nuts holding down the valve, and the security bolts, must be screwed nearly off, and the valve and bolts pushed well back into the tire. The side of the cover nearer to you should then be pressed away from you all round the wheel, so as to unstick the edge, bead, or rib of the cover from the edge of the rim. Now take two tire levers and thrust them down between the edges of the cover and rim, about nine inches apart. Do not push the levers too far in or they may damage the air tube. Press down the outer ends of the levers, so as to raise the edge of the cover above the edge of the rim. If you have a helper, let him insert a third lever, about nine inches beyond the second, and pull it down like the others. But if you are alone on the job, pull the first lever down to the vertical and secure it by a loop to one of the spokes. The loop should be put around the spoke before pulling the lever down. Having secured the first lever, move the second further along and pull it down again. Quite a number of special tire levers have been introduced, some of which are much easier to manipulate than the ordinary bar levers. Repeat the levering until a good portion of the cover has been pried over the edge of the rim; the rest can be worked out by hand. The valve may now be completely removed from the rim, and the air tube withdrawn from the cover.

It may be that there is a leak between the head of the valve and the air tube, and this may generally be cured by tightening the nut which secures the valve to the tube.

In cleaning the cover, however, one may have come across a cut, or the head of a nail, or other interesting object, indicat-

ing a puncture, and the interior of the cover should be carefully examined to see if any nails or the like are projecting through the inner surface, and also to see whether any parts of the lining are discolored by the penetration of wet through cuts in the rubber. Wet rots the canvas very quickly, and such spots should be treated both from without and from within.

Advantage of Spare Tubes.

Repairing a puncture in a motor car tire is a much more serious affair than dealing with a similar trouble in a bicycle tire; and, even with light car tires, unless the patching process is very carefully and patiently carried out, the result will not be satisfactory. Hence it is much better to carry one or two spare tubes, and insert one of these, than to attempt to execute a repair by the roadside.

Vulcanized Tire Repairs.

The unsatisfactory results too frequently attaching to attempts to repair motor car tires by the ordinary patching system have led to the introduction of small vulcanizing plants, some of which are portable enough to be carried on a car, and indeed are specially constructed with a view to this. The system differs essentially from patching, in that the damaged part is remade instead of merely repaired. In the case of a punctured air tube, the rubber round the hole is cut away so as to form a beveled or concave seating extending right through the wall of the tube. This gives a fresh surface of large area. The cutting may be effected by gouging, or by folding the tube so as to bring the puncture to a corner, and then snipping off the corner with a pair of sharp scissors. The tool should be wetted, as rubber cuts much more easily when wet than when dry. The fresh surface is then roughened by rubbing with sandpaper or a small rasp to facilitate penetration by the flux, which is next applied thereto. This flux is a solution of raw rubber mixed with sulphur and other ingredients. When the first coat of flux becomes sticky, a second

may be applied, and this should also be allowed to reach the "tacky" stage before the next operation is proceeded with.

It is convenient while doing this part of the work to tie the air tube down flat, as, for example, across the top of a wheel with a sound tire.

The next thing to do is to fill up the enlarged hole with rubber compound, which is a similar material to the flux, but in a plastic or putty-like state. It is well to warm the compound, as by dabbing it on the vulcanizer, before kneading it into place. The compound should be pressed well in, and rather more than enough applied. The surplus should be trimmed off with a wet, sharp knife, great care being taken not to cut the tube in so doing.

A typical apparatus consists of a small brass boiler with vertical fire tubes. One side of the boiler is made flat to adapt it to the vulcanizing of air tubes; the opposite side is concaved to suit the contour of the outer surface of the purchaser's tire covers. The water is filled into the boiler through an orifice at the top until it runs out at the blow-off cock, which also forms part of the steam pressure gauge on the boiler. The furnace consists of a cylindrical alcohol lamp. The spirit is soaked up by cotton-wool located in the cylinder under a wire gauze burning surface. The lamp telescopes into the lower part of the boiler, and the heat can be regulated by pushing in and drawing out a sliding sleeve or extinguisher to a greater or less extent. A detachable metal arm is secured to the upper part of the boiler, and forms a handle by which the vulcanizer can be moved about. The bent outer end of the arm forms a bracket, and carries a screw between the end of which and the flat surface of the boiler the air tube is gripped during the vulcanizing process. A metal plate and a block of wood or vulcanized fiber are introduced between the point of the screw and the air tube. The vulcanizer is fitted with a socket whereby it can be mounted on the rear light lamp-bracket when repairing air tubes, and with a detachable chain device whereby it may be secured directly to the wheel in the case of repairing a cut cover.

It should be clearly understood that the boiler is employed simply because it provides the most convenient method for securing the necessary heat. There is no magic in the heat being produced by steam. Further, the steam pressure has nothing to do with the pressure exerted on the tube or cover under repair. The pressure of the steam is merely useful as indicating in a convenient manner certain temperatures corresponding thereto. As it takes some ten or fifteen minutes to raise cold water to the necessary steam pressure of 50 lbs. to the square inch (corresponding to a good vulcanizing temperature of about 281° F.), it is advisable to start the boiler before preparing the punctured part of the air tube, and also to use warm water (as from the radiator) instead of cold.

The injured tube having been treated as above described, and the indicator on the boiler showing 50 lbs. pressure, a piece of tissue paper or linen, rather larger than the flat surface of the boiler, is laid on the part of the tube, which is then pressed flat against the boiler by means of the screw and plates. The screw should be turned by the fingers only; this will give sufficient pressure. The paper or linen prevents the rubber compound sticking to the surface of the boiler. The wood or fiber plate should not be so large as to reach and pinch the edges of the air tube. If the wound is a large one, instead of a mere puncture, it should be treated in a similar way; but it is then as well to insert a piece of tissue paper in the air tube, so that the repaired part shall not stick to the opposite wall when vulcanized. After about a quarter of an hour the sulphur will be thoroughly melted, and the raw rubber compound thereby vulcanized.

The tube may now be removed from the vulcanizer, and if the thumb-nail be dug into the repaired part, the impression should quickly disappear when the nail is removed, otherwise the vulcanizing should be carried on for a few minutes longer. The time varies with the thickness of the article being treated, not with the size of the surface. A gash will take no longer to vulcanize than a puncture, but a thick tube should be given about twenty minutes instead of fifteen.

Cuts in the cover are treated substantially in the same way. The rubber should be cut away around the injury right down to the first canvas, and at such an angle as to expose a large surface of fresh rubber around it. It is then rasped and treated with one or two coats of flux, and after the last of these has become tacky, the hole is filled up with compound, well pressed in with a roller tool provided for the purpose, and pared off flush with the surface of the cover. Meanwhile the vulcanizer has been getting up steam on the bracket. The damaged portion of the cover is brought to the back or front of the wheel. The injury is covered with paper or linen, and the vulcanizer is secured to the wheel, with the concave side to the injury, by means of a chain which should be screwed up fairly tight, but not so as to indent the cover materially. Owing to the greater thickness of the material, the heat will have some difficulty in penetrating it. A pressure of 60 lbs. may be used for about fifteen minutes, twenty minutes being necessary for 50 lbs. The cover should be perfectly dry, and the dryness may generally be obtained by putting the vulcanizer in position before the required pressure has been obtained, so that the moisture may be evaporated before the 50 lbs. or 60 lbs. has been reached, and before the vulcanizing has commenced. A pad of cloth should be placed temporarily between the cover and vulcanizer to let the damp vapor escape. Special adapters can be obtained for covers of special formation.

The above described vulcanizer weighs about 10 lbs. More elaborate ones are made for garage use, and are provided with means for repairing burst covers. In the case of an ordinary burst, the cover should be turned inside out, and a large piece of the lining should be cut away right across the inside of the cover. Then the material should be cut away in layers extending to the depth of one canvas each. The portions of canvas cut away should be of rectangular form with rounded corners, and each layer should measure about one and a half to two inches less in length and breadth than the one previously removed. The last layer of canvas should not be cut out, but should be left bare to the extent of about one inch all

round the burst. During this operation the portions of fresh canvas should be cut to the shapes of those detached, and saturated with the flux, successive coats being applied and allowed to get "tacky" until a substantial film of rubber is left on both the surfaces. The steps cut in the cover should be coated with flux in the same way. The cover is now turned back again outside out. The wound in the tread is treated as before described, and the patches of canvas are laid in position, and pressed down with the roller. The last piece should be considerably larger than the others, and as it is to replace the damaged portion of the lining, it should be solutioned on the back only. When this is in place, the cover is put in the vulcanizer between two properly shaped steam containers, one inside and the other out, and it is bound down tightly to the inner container by a strip of webbing wound on spirally. The parts are gripped thus, and a pressure of 60 lbs. is kept up for about twenty-five minutes, or longer if necessary.

Air tubes may be joined, and other jobs done in a substantially similar manner.

Repairs by Patching.

In the absence of a sound spare tube and of a vulcanizer, the patching process will have to be resorted to. The air tube should be examined for one or more punctures. If the trouble cannot be ascertained by mere inspection, the tube should be reinflated lightly, and immersed and stretched, bit by bit, in a large bowl of water, when the seat of the injury will be discovered by a stream of bubbles issuing from the puncture.

Draw a ring on the tube, concentrically with the puncture, with an indelible ink pencil. As this is to serve as a guide to the position of the hole during the subsequent operations, it should be rather larger than the patch to be applied. The surface around the puncture and within the ring must be thoroughly cleaned. Gasolene is very useful for cleaning off the sulphur and preparing the rubber for the solution. A block of sulphur is also handy; but the usual process is to wrap a piece of glass paper round something hard, such as the chalk case, and rub

the tube clean around the seat of the injury. When all the sulphur has been removed, a thin film of indiarubber solution should be spread on the prepared surface. The area of the film should be sufficient to extend well beyond the edges of the patch to be applied. This film should be allowed five or ten minutes to dry, and another spread over it, and subsequently a third. If the films of solution are exposed to the direct rays of the sun they will dry quickly.

One of the rubber patches in the repair outfit should be chosen according to its size, and this also should be cleaned and given three coats of solution, each being thoroughly dry before the next is applied. If the patch shows an irresistible desire to curl up, encourage it to embrace a fixed rod of suitable diameter, so that it shall not roll about and get covered with dust, etc. The patch should then be carefully laid on the solutioned part of the tube, which should be quite empty of air at the time. The patch should be firmly pressed down on the tube, the pressure being applied from the center outward, so as to drive out any bubbles of air that may have been caught between the patch and the tube. The patched portion of the tube may be laid between two flat plates and moderate pressure applied, as by a vise or a weight. When the patch is well set, it should be further secured by a much larger canvas-backed patch solutioned on in a similar way, the canvas being outward.

If the puncturing object has penetrated right through the tube, of course both holes will require mending; and a second hole should always be carefully looked for. Sometimes one puncturing object will make quite a lot of holes close together. Try to cover them all with one big patch.

Treating the Cover.

Outwardly, the hole in the rubber should be carefully probed and freed from grit, and then cleaned with gasolene, benzene, or the like solvent. The surfaces of the hole should next be solutioned with two or three coats, and the wound bound up until the solution has set. If the hole gapes, it should be

plugged with some of the stopping preparations sold for the purpose. Inwardly, the weak place in the fabric should be reinforced by a piece of prepared canvas extending not only the full width of the cover, but a short distance up the outside as well, so as to be gripped by the rim. This should be carefully solutioned in place. The canvas should be cleaned with gasolene before applying the coats of solution, plenty of which will be necessary. The cover ought not really to be used for some twelve hours or more, hence the advantage of carrying a spare cover; but if none has been brought, the damaged part should be relieved from strain either by lacing a gaiter round the cover and felloe of the wheel; or, if this cannot be done, a short canvas sleeve may be sewn around the air tube. This sleeve should be large enough to allow the tube to assume its ordinary diameter, but small enough to relieve the cover from strain. Care must be taken not to prick the tube when sewing the sleeve. Actual bursts in the cover must be treated in the same way, but on a larger scale. If a gaiter is employed, it should be laced on while the tire is only lightly inflated. When the inflation is completed, the extra pressure will cause the gaiter to set very closely, as it should do.

Stripping the Wheel.

In case the cover has to be completely detached from the wheel, pull down the bolts near the top of the wheel, and insert two levers, about nine inches apart, under the remaining edge of the cover. Press on the outer ends of the levers, and then push them forward, so that they bridge across the rim, resting on both edges thereof. The edge of the cover at the top of the wheel will now lie on the levers, and may be drawn along them across, and over the edge of, the rim. Pressing down the handles of the levers will assist the operation. When the cover is thus released from the top of the rim, it may be easily withdrawn from the rest thereof.

Before reinstating the tire, the interior of the cover should be liberally dusted with powdered talc, generally called French chalk. Blacklead or grate polish (or, more properly, graphite)

forms an efficient, though dirty, substitute for the chalk. All solutioned parts in the cover and on the tube should receive special allowances. Sometimes a quantity of grit and dirt will accumulate in the cover; this may be picked up with a small lump of soft clay or putty.

While the rim is bare, take the opportunity of seeing that it is clean, free from dents and rust, and well covered with enamel. If there are any bare or rusty patches, and it is not convenient to enamel them at the moment, give them a wipe with a greasy cloth, as rust rots canvas quickly. The grease must be cleaned off thoroughly before applying the enamel.

Replacing the Tire.

If the bed of the rim is uneven, see that it is covered with an evenly-laid tight tape. Straighten or replace any security bolts that have got bent, and push them up from the bed. Put a few pumpfuls of air into the inner tube, and place in position in the cover, while the cover is still off the rim. Be very careful to get the valve stem comfortably into the notches in the cover. Turn the wheel round until the valve hole is at the top. Now very carefully place the tire on the upper part of the wheel, so that the further edge goes into the rim, and the valve can be put into its hole without straining to right or left. Work the further edge of the cover into place under the edge of the rim and under the heads of the bolts. Much of this can be done by hand; the levers must be used for the rest.

The parts are now in the position they occupy when the cover has been opened merely, not entirely detached from the wheel. Supposing the air tube has been withdrawn, and is to be replaced, the stem of the valve should be passed into its hole and the valve completed, except for tightening the outside locknut; and the heads of the bolts should be pressed down into the bed of the rim. The tube should be slightly inflated and tucked into the cover, care being taken not to twist it, or to disturb any of the patches. Pass the hand round between

the air tube and the rim to make sure that the tube is not caught by any of the bolt heads.

The valve and bolts are next pushed up again, and the other edge of the cover is got back into the rim like the first. The bead may be helped under the edge of the rim by prodding it with the end of the tire lever; but if it is very obstinate it probably means that the air tube has got down between the edges of the cover. If this is suspected, it is much the best to open the tire again, and then reinsert the second edge of the cover, as a nipped tube spells disaster, none the less deadly because deferred. A little judgment is required to pump the air tube tight enough to prevent nipping in this way, and yet not so tight as to prevent the second edge of the cover being got back into place. If the security bolts can be moved up and down in their holes without difficulty, it generally shows that the tube is not being nipped. When satisfied on this point, you may tighten up the nuts of the valve and bolts, and put a little more air into the tire.

The wheel should now be slowly rotated, and the tire pulled and pushed laterally, and pommeled well with the fist. This enourages the parts to assume their proper positions. After a due amount of exercise of this sort, the tire may be fully inflated, and the nuts of the valve and security bolts given a final turn.

Miscellaneous Hints.

After running a few miles, go over these nuts again. It is important to have them tight to prevent the tire creeping or wrenching or blowing off, and to prevent water getting in. Turning corners too fast is a frequent cause of the tires coming off if the bolts are loose; and if the tires are too weak or the speed too high, the cover may split along at the edge of the rim. Under such circumstances a temporary repair may perhaps be made with a gaiter, etc., but a permanent repair is often impossible. Tires stand best when the inflation is kept well up to the mark. If the tire gets flabby it will get pinched between the rim and the ground, will let the water

in, will wear out rapidly, will be more likely to sideslip and will waste power.

Cheeseparing does not pay with tires. Have the covers retreaded as soon as they are worn enough to show the first ply of canvas. Do not try to fit the tires of one maker to the rims of another, unless the tire maker approves. Have all difficult repairs done, or completed, as the case may be, by the manufacturers of the tire.

In case a tire is damaged beyond repair, one may remove the air tube and stuff the cover with hay or any other suitable material that may be at hand; or one may lay some thick coils of rope round the rim. But these are expedients only to be resorted to when "in extremis."

If the car is to be put away for any length of time, it is best to jack up all the wheels and to inflate the tires only hard enough to keep them in shape. They should be wiped over occasionally with a rag dipped in warm water, and should be kneaded to maintain their suppleness.

As to solid tires, little advice can be given, except that they should be examined with a view to ascertain that their means of attachment are secure. Any large cuts should be picked out and mended as above described in relation to the covers of pneumatic tires.

Care of a Car on Tour—The man who starts on tour starts with the risk of trouble—unless his outfit is complete, and it is with a view of eliminating all sources of worry that one can lay to one's own charge that the following paragraphs deal with the necessary preliminary preparations to forestall avoidable mischance.

First, says a noted European motorist, the tires should be taken from their wheels, the rims sandpapered inside, and the bed of the rim enameled with some quick-drying enamel. Next the heads of the security bolts should be examined as to their covering. They will generally be found a mass of crumpled leather. Replace with repairing canvas by cutting two pieces to the required shape, snip a small hole in one of the pieces for the stem to pass through, and then press the

solutioned sides together and trim up with scissors. Now rub the inside of the cover round with a duster, run your hand round critically for any bits of flint or other puncturing material that may lurk therein, and look for any signs of cracking or chafing in the lining canvas. If you find a suspicious-looking place, put a patch on, for there is nothing worse for your tube than an apparently insignificant weakness of the cover. The tube seems to chafe through at such spots, even when there is no actual perforation of the cover further than perhaps one or two layers of the inner canvas. In replacing the covers use plenty of French chalk, without overdosing, or you will find it in cakes when you take them off the next time; chalk your tube, and put a little air in before you get the last edge of your cover off. Blow them up hard; they stand a better chance of retaining the air, especially if there are any patches on the tubes.

Engine Treatment.

Next, you must put your engine in proper trim, and to do this thoroughly will take both time and patience, to say nothing of a suit of overalls, and, if possible, an inspection pit. There will no doubt be doors of some sort to the crank-case, so that you can discover whether there is too much play in the connecting rod brasses (bushings). Put the particular crank you are investigating on the bottom dead center, grasp the connecting rod, and see if you can move it up and down; if there is any play, say 1/32 inch, the brass had better be taken up.

It will depend on the position of the inspection door how you go about this job. If you have one on each side, it will be easy to get a spanner to the nuts on the big end; drop the cap and the bottom brass, then push the piston and rod up out of the way, and pull the top brass out of its seating. Now place the brasses on the crank pin, hold them together with thumb and finger, and see how much shake there really is. Let this be your guide in filing the edges of the brasses, to do which it is best to lay the smooth file on the bench and

A Stoddard-Dayton Touring Car.

tive positions of the exhaust valves and pistons. Where there is a compression cock, push a piece of steel wire, such as a bicycle spoke or a knitting needle, through the orifice, and feel the piston-head as it rises on the exhaust stroke. The valve should shut when the piston is at the highest point. If you have mechanical inlet valves, they should commence to open at the precise moment, or immediately after, the exhaust valves close—that is, when the piston is just at its highest point.

Ignition.

In overhauling the ignition apparatus, it is well to begin at the source of your current, which will most likely be in the form of accumulators or storage cells. Disconnect them from the primary wires, and if they have transparent cases, look at the plates, which should be alternately plum color and grayish blue. See if any particles threaten to bridge the space between positive and negative plates, and if there is much sediment in the bottom. These are both prolific causes of short circuit and untimely failure of your supply of electricity. If all appears well within, test them with a testing lamp of the proper capacity. Four volts two ampères is about the right thing, and if such a lamp burns brightly for several minutes without diminishing in intensity, you can conclude the battery is all right. If you use a voltmeter, it should show over four volts, but under no circumstances use an ammeter, or short the terminals with a file. In one case you will fuse the wiring of the instrument, and in the other you stand a good chance of buckling a plate or loosening some of the paste from which the plates are built up. Before connecting the wires again, see that the terminals are bright and clean, also the ends of the wires; tighten up the nuts with a pair of pliers, and smear with vaseline, or, better still, wrap the lot up in rubber tape. The casual screwdriver or what-not falling across the terminals will then fail to bring about your undoing.

Adjustment of the Coil.

One of the battery wires will lead to the switch, thence to the frame, where it should make a good and sound con-

nection; the other goes to the coil, where it should connect to the primary terminal, generally marked P. The current supplied by this wire now traverses the primary winding of the coil, and comes out at the terminal marked M or T—motor or trembler. The wire from this terminal goes to the contact breaker, and is connected to the blade thereof in the case of a wipe contact, or to the platinum-pointed screw in the case of the make-and-break type. The make-and-break contact will probably require some attention in the shape of filing up or cleaning the platinum rivets on the blade and adjustable screw. Take care when reassembling that the distance between blade and screw is equal in each case—i. e., where there are two or more cylinders—and that the platinums come hard together, backed up by the spring of the blade. Good flat contacts should be filed, or there will be misfiring when you get going.

See that all the blades are the same length; when they are unequal, as is often the case, the cylinders do not all fire in the same relative position of the crank, and loss of power and irregularity in running are the result. The wipe form of contact requires very little attention, but it is well to see that the brass segment is not worn below the fiber, or there will be sparking. The remedy is to turn it up again in the lathe, until the brass is level with the fiber. Now see that your high-tension wires are connected properly at the coil, and when satisfied on that point, take out your plugs and lay them on the cylinder cover; connect up, switch on, and turn them on the round by hand until the trembler on the coil buzzes. If there is much sparking, these contacts will have to be filed up and the screw adjusted, to give as high a note as possible without sticking. Switch on and off rapidly, and see the trembler responds every time, and that there is a spark at the plug simultaneously. When you are satisfied on these points, you can replace the plugs and turn your attention to the carbureter.

Examine the Carbureter.

Carbureters are of so many different patterns that it is difficult to prescribe any hard-and-fast rule for dealing with

them. Generally speaking, one should examine the float to be certain that the gasolene does not get inside, and if it has been standing some time immersed in the spirit, a shake will determine if it is empty or not; then take out the needle valve and turn on the gasolene. It should flow freely into the float chamber; if not, clean out your supply pipe and gauzes. The jet may be cleared with a strand of copper wire, such as is found in your electrical outfit, or in the case of the Longuemare type, the spraying cone can be removed and the channels cleared with a penknife. Do not clean them too vigorously, or you may remove some of the metal and cause the spray to deliver too much gasolene. It may be advisable to grind your needle valve with a touch of knife polish, finishing with some pressure but without emery. This should show a bright appearance when the cone of the valve fits the seat, and when the brightness extends all round the valve will be quite tight. In order to keep the valve upright during this process, it is best to put the cover on the float chamber and secure with two or three screws.

The Change Speed Gear.

By moving the gear-changing lever into the several notches of the quadrant, you will see whether the wheels are in line with one another, and should they be otherwise there will no doubt be some form of adjustment by which you can make them so, and perhaps at the same time neutralize to some extent the wear that has taken place on the tooth sides by setting the sliding sleeve further over. This will require some thinking out, as in some cases the speeds are divided up in pairs, and the remedy for one pair will be at the expense of the other.

In case of three-speed gear with direct drive on top speed, the second speed can be set over by deepening the recesses in the positive clutch which locks the divided shaft together, but this is a last resort when the gears are nearly at the end of their tether. The shafts should be tried for wear in the bearings, and, if considerable, the brasses must be taken up in a similar

manner as explained for the connecting-rod brasses; or, in the case of plain bushes, they should be renewed.

Look After the Chains, If Any.

Chains should be soaked in kerosene, dried, and immersed in hot tallow. If considerably stretched they should be renewed. It is hopeless to endeavor to remedy a stretched chain by means of the adjusting rod. This is only useful up to a certain point, say to the extent of one link, but after that link has been taken out the difference in pitch between the chain and the sprocket becomes too great for the chain to run properly, and it is forced to ride up the teeth in its endeavor to find its proper pitch circle. At this stage it will save much trouble to invest in a new pair of chains.

Brakes and Bearings.

Give your brakes some attention, and in effecting adjustments be careful to take up equally on each side, or the car will swerve when they are applied, but if you have some compensating device this precaution is unnecessary. The wheels should be separately jacked up, and if showing signs of shake in the bearings should be adjusted, but always leaving just a trifle of play. The axle-caps should be filled with grease before screwing on. By giving the wheel a spin, the presence of a broken ball may be detected, and, if found, removed, and replaced by one of exactly the same size. If it is impossible to procure one which your calipers assure you is the same as the others, it is far better to leave one out than to put in a larger one, though a smaller one would not so much matter. When replacing the gear-box, you should adjust the countershaft brake, and, if necessary, replace the lining of the band.

Attention to Steering Gear.

See that your steering gear is all correct, and if of the direct type be sure the pins on the steering arm, distance rod, and divided axle are securely nutted and pinned. It may not be possible to adjust for wear, but if you have worm and sector or quick pitch thread and nut there should be means of adjustment, in the first case by setting the worm deeper in gear,

and in the second by letting up the halves of the nut. In any case, it is very desirable the car should go exactly in the direction you require it, and backlash on the steering gear is irritating, to say the least.

Cleaning out the Water-circulating System.

The water circulation can conveniently be inspected while you are under the car attending to the steering gear, and if you suspect anything faulty, disconnect the several unions, and wash through the radiators, pipes, tanks, and cylinder jackets with the hose and a good force of water. An obstinate block in a pipe will generally yield on the application of heat. Methylated spirit (wood alcohol) on a piece of waste will answer capitally, but the gasolene tank should be empty, or the refractory pipe removed to a safe distance while this operation is going on. The same process may be applied to radiators, with the proviso that you do not carry the heating far enough to melt the solder. The obstruction will generally be found to consist of grease, or some foreign body incased in grease. Boiling water may be applied if you have it handy, and with the addition of washing soda is excellent for tanks. Pour it in hot, and leave for a few hours, and your tank will scale beautifully.

Accessories for the Tour.

If the reader has attended to all the points mentioned in the preceding paragraphs, and has satisfied himself that things are correct, or, if not, has made them so according to the instructions given, he is at last prepared to set out on the projected tour. It now behooves the would-be tourist to collect the necessary impedimenta, which may consist of the following articles:

Spare cover, which may be wrapped in a strip or bag of suitable material; such bags, complete with straps, can be bought of many dealers.

Spare inner tubes—two or more, having regard to the space available.

Repair outfit, with an ample store of solution, patches, and canvas.

A few tire gaiters or tire sleeves. The eyeleted kind require woven steel cable, which is damaging to the fingers, though they can be laced with rawhide thongs instead. These thongs are most useful things to have in your repair kit, as in the event of a burst they can be used as a gaiter by attaching one end to a spoke and winding over the rim and cover in a spiral, and fixing the other end to the next spoke. For this purpose, you will want long ones (6 ft. or so), and they should be applied with the tire deflated; the subsequent inflating pulls them tight on the cover, and if they constrict the part on which they lie, to some extent, so much the better—they will wear all the longer. A tip in putting gaiters and thongs into requisition is to start wrapping some inches behind the burst, when this is in contact with the ground, so as to counteract the creeping tendency.

There are a great many makes of solution on the market—some very good, others indifferent. One "special motor solution" appears to be rubber dissolved in carbon bisulphid, and has an overpowering odor. Some drivers swear by it; much depends on the relative size of the tire to weight of car. The experience of others has been that the rapid evaporation of the solvent produces condensation of atmospheric moisture on the surface of the solution, which prevents the patch sticking. You may be certain that if your car is under-tired there will be constant trouble with patches. Some have found that a canvas patch on the back of the rubber patch, extending an inch or so beyond it all round, helps to keep it on, but nothing short of vulcanization will make a sound job. See Vulcanizer.

Tools, etc., for the Tour.

These may include a strong adjustable wrench; a set of tube spanners; a small vise to fix on mud-guard or step; a hack saw and half a dozen blades; a set of files (one 10-inch flat second cut, one half-round, one square, one round, and a few small warding files); a brace and several sizes of drills,

also a screwdriver to fit brace, and one or two center bits for wood; a large screwdriver; two hammers (one heavy, one lighter); a lifting jack to suit car axles; links of chain and connecting bolt; a pair of flat-nosed cutting pliers; a small adjustable wrench; a box of assorted nuts, bolts, and split pins; assorted wood screws; copper wire; rubber hose for pump connections; sparking plugs; insulated wire.

Experience will dictate a fairly complete outfit, and, although occupying a good deal of room, such will be worth taking. Having filled the tanks and lubricators, strapped your baggage in the most convenient place, and donned your motoring garments, you set out on your adventurous career.

Stabling of a Car.

At the end of your first day's journey you may elect to spend the night at some village hotel. The chances are that you may not find much accommodation for the car, and here a sheet of waterproof canvas or a properly-made car cover comes in. The latter is provided with cords for fastening down, and is shaped roughly to the vehicle, but a plain sheet 12 ft. square or 12 ft.x14, or 16 ft., according to size of car, will do very well, and only cost half as much. Make fast all round; it will prevent the wind blowing it off, and also tend to preserve any little odds and ends you may have left lying in the tonneau or elsewhere from being annexed, or the lubricator from being turned on by meddlesome people. Before starting in the morning you will gauge your gasolene by dipping a clean stick or rod in the tank, if an indicator is not fitted, and estimate the mileage per gallon used on the previous day. The oil reservoir should be examined, and perhaps by adjusting the carbureter and oil feeds you can obtain better results. As everything has just been tightened up, it is better to err on the generous side for the first day or two as regards lubrication, but if there are indications of overdosing this will easily be seen in looking over the car while running. Half an hour devoted to going over the nuts and bolts which you disturbed in your overhauling will be well spent.

Tire Repairing.

Suppose you experience a curious bumping sensation or hear crackling sounds in the neighborhood of the offside driving wheel, and take a cautious look back to find the tire flat as a pancake. On stopping the car, you will be able to tell by the valve stem if the tire has been down long, for if so it will have assumed a tangential position, owing to the creeping of the inner tube, and then the jack will be requisitioned, as the tube must be taken out bodily for repairs. You will probably put in a spare tube, and after dusting it with a little French chalk, replace the cover, inflate the tire, and drive away. But, on the other hand, you may be able to see the actual offender sticking "in flagrante delicto" from the cover in the shape of a horseshoe nail. Then you will merely remove a couple of feet of cover, fish the tube out, and put a patch on the puncture, not forgetting the extra canvas patch previously mentioned. Look out for nips in replacing the piece of cover. The whole repair is only a matter of minutes, because you have the advantage of knowing the exact location of the trouble.

Leaking Patches.

To take another case of deflation, we will suppose you can find no external evidence of puncture, and knowing the tube to be patched you half suspect one of the patches of having sprung a leak. You attach the tire-pump, and gingerly commence putting some air in; the tire begins to regain its rotundity. So it was only a leaky valve, after all. Vigorous strokes at the pump. Hark! a curious sibilant sound. It's that confounded patch, after all. Your ear will tell you whereabouts the leak is, so only remove as much of the cover as will enable you conveniently to attack the job. You will very likely find that, although the air has burrowed a small channel between the patch and the tube in one place, other portions of the patch are holding on tenaciously. Why they do not stick all over alike is what most owners never can understand. However, while you are wondering, the folks in the tonneau are getting cross, so you must get to work.

Removing Patches.

A drop of gasolene applied with care does wonders in persuading the patch to peel off, and afterwards in cleaning the surface of the tube; but do not apply the solution until you have well roughened the place with glass paper. Put the old patch away for future use, and apply a fresh patch, two coats of solution, spread on thinly and well rubbed in, especially the first (you cannot rub the second coat hard, or the lot peels off), squeeze the patch and tube together as hard as possible with finger and thumb, beginning in the center of the patch and working out to the edges. You may hold a block of wood under the tube and beat the patch with a hammer, if preferred, but go gently. Some men belabor their patches unmercifully, and say they never come off; but judicious beating is generally preferred.

Treating a Burst.

In the case of a burst, it is better to remove the entire cover, if you can spare the time. Clean out the inside with a piece of rag damped with gasolene, and, when dry, fix in a piece of thick canvas which is large enough to go right across and lap over the beaded edge on each side. While this is drying, attend to the tube as previously directed, and after replacing the cover and tube, inflate the tube to a slight degree and apply the tire gaiter. It is quite easy to remove a tire without the aid of a jack by rolling the wheel backward and forward. The procedure is as follows: Remove as much of the bead as you can from the side of the wheel nearest to you, and then take out as much tube as the circumstances will permit; then roll the car forward bodily, and the rest of the cover can be detached and the tube entirely taken out. After taking out the security bolts, with the tire lever you can get the inside bead over the outside lip of the rim as far as the ground, and by rolling the car backward a few feet the cover will be free.

Replacing the Tire.

In putting back the cover, reverse the process, only taking care the valve hole comes right with the places in the tire

bead intended for the valve stem to pass through. If, when your first bead is in, you find the valve hole is not opposite the gaps, by rolling the car forward or backward, as the case may be, you can set up a creeping action in the cover that will bring the hole and gap in line. For instance, if the gap is to the right of the hole when you are repairing the right-hand tire, the car must be wheeled forward to effect the purpose. Such a repair as is indicated will not last long, and the cover will have to be vulcanized to be efficiently restored; but supposing you have no spare cover, and do not want to abandon your tour, a fairly good job can be made by any saddler in the town where you stay for the night. Get him to sew a piece of rawhide inside the cover, bringing the stitches through to the outside and herringboning over the gash so as to draw the lips together. If you find the canvas previously put in adheres firmly there is no need to take it out, but sew through the lot. It is a good plan to knot each stitch separately, because in that case if one stitch give it does not loosen the others. The difficulty is to get anyone to take the trouble; the remedy is to do it yourself. When the gash or burst was a large one some drivers have used a tire gaiter inside, first cutting off the eyeleted edges; but this plan has the disadvantage of spoiling a gaiter for outside use. It is well to put another gaiter outside in addition.

Supposing the burst is not of a serious enough character to demand so much reinforcement, you need only stitch another canvas patch over the rawhide, which you have sewn in, to prevent chafing on the edges or threads, and the repair is complete. Properly done, this job will last for hundreds of miles. Of course, if the burst is on or near the tread, the outside gaiter or sleeve must be used to protect the threads from cutting.

More about Tires.

It is a good plan to sink the threads below the surface of the rubber carefully by cutting a slit joining the holes where the thread comes out and goes in at every stitch. Do not cut down into the canvas; you will have to exercise judgment in

making the incisions. After making the slit, pull the thread tight, and the loop will disappear below the surface of the tire. The thread is now protected, and has also got a better hold of the canvas.

If you are a real enthusiast there will always be plenty to do in the evening after you have dined—little adjustments of the running gear, and perhaps tire repairs—and provided with an electric lamp you can continue your labors after dark, so as to waste no time in the morning. Washing down should always be done under your own inspection, or when next you essay to start away the carbureter will be found full of water or the tremblers submerged. Before applying the hose, look round the tires, see that the wing nuts are tight, and stop any small cuts in the cover with some stopping material. If wet gets inside it will surely cause trouble. See the car thoroughly dried before it is put away for the night. Steering joints are apt to rust up unless protected with coverings. The latter should be fitted to every car, as they are easy to make, and save no end of bother and fatigue from stiff steering.

Misfiring.

The chief complaint from which engines suffer is the fault of missing fire. A fruitful cause of irregular ignition is weakness of the accumulator, so when it occurs you will begin at that end of the electrical gear and satisfy yourself that all is well with the battery. Next have a look at the other end—the plugs—and then go over the ground between. Are the contact blades rubbing firmly on the cam? Are the tremblers on the coil vibrating angrily? You will find out by opening the compression cocks and turning the engine slowly. Suppose one trembler is only fluttering. You remove the contact screw and find it badly pitted. The rivet on the blade has a minute point fused on it, just opposite the part of the screw that has become pitted. A few strokes of a smooth file, a little adjustment of the contact screw, and you are rewarded with a buzz that can be heard some distance away. It may be a high-tension wire that has touched the exhaust pipe and lost its insula-

tion, or a low-tension wire that has chafed against a water pipe, or a loose terminal on the contact breaker. Sometimes the earth return wire gets broken where it is fastened to engine or frame, and then the misfiring will occur intermittently, first in one cylinder and then in the other, leading you a pretty dance until you stumble on the cause. A wipe contact should have ample means of return. The film of oil on the bearings of the second speed shaft and the other resistances between the little brass inset and the frame of the car are almost certain to interfere with a free return, so it is better to provide some other means of return, such as a wire attached to the plate on which the blades are mounted and connected to a nut on the engine or frame. A good plan is to fix a supplementary blade to rub on the center of the fiber cam so as to make contact on the shaft on which the cam is fixed, and ground the wire from this blade.

Examine the Carbureter.

If you are sure the ignition is all right and the missing still persists, suspect the carbureter. A partly blocked gasolene pipe will produce the symptoms, so remove the nut which connects the gasolene pipe. with carbureter, and try blowing back into the tank with the tire pump. This is the rough and ready method. If it fails, disconnect the pipe altogether, and see if it is clear. The pump will clear it if you can make a joint of some sort, either by removing the valve connection or using a bit of rubber tube, or even wrapping a piece of rubber strip round and wiring it in place. The obstruction may be in the narrow orifice below the needle valve; you can find out by dismantling the carbureter. There may be a particle of dirt in the spray nozzle, which gets carried up occasionally to the tiny hole that delivers the gasolene jet, and occasionally drops back to the bottom of the passage. Clean the jet out thoroughly and wash through the passages with gasolene, when no further trouble should be experienced on the road.

We have heard of the case of a Chicago owner, a motorist of sagacity and experience, whose gasolene tank ran dry while

he was touring in Illinois. He managed to reach a town and the shelter of a fair hotel and as it was getting toward evening he decided to remain overnight, and replenish his fuel supply. In the morning, however, his engine refused to run. Suspecting the carbureter, he made a thorough examination and, as he thought, left nothing undone that should have been done under the circumstances. But the engine still balked, and he wired to Chicago, 75 miles distant, for an expert mechanic. The afternoon brought the mechanic, and in ten minutes he had discovered that the spraying nozzle was choked up by particles of dirt which had settled to the bottom of the float chamber, to be drawn into the jet when the tank ran dry. Another five minutes remedied the trouble—and that owner will never again forget the weakness of that particular point in his machine; in fact, it is safe to say that in future, when he suspects the carbureter in diagnosing trouble, the spraying nozzle will receive early attention.

Care of Car—See Overhauling.

Care of Grease Lubricators—See under Lubrication.

Care of the Hands—There are several conditions which, if understood, save much trouble in cleansing the hands after motor work. From experience it will have been noticed that the sole reason for motor dirt being hard to remove is the irregularity of surface to which it is applied. Cracks round and under the nails are the most difficult places to clean, next the creases on the fingers and thumbs. Given a smooth hand, very little dirt will stick. Therefore, do all that is possible to keep the hands smooth. This is a cardinal point. To do this there are several points to observe—

1. Remove the dirt without roughening the surface.
2. Fill the interstices of the skin before starting work.
3. Avoid chafes, chaps, and rubs, that is, knocking the skin off the knuckles and exposure to wet and cold.

Avoid all coarse forms of soap; never scrape the nails with a knife; never use any alkaline substance whatever. Do not use gasolene to wash hands in; it coarsens the hands very quickly.

Gloves are uncomfortable to work in, so before beginning to work, rub the hands all over with a fine toilet soap, fill the nails and cracks round with it, and avoid contact with water till the job is over.

If necessary wear gloves with the finger ends cut out.

To clean the hands, use warm soft water, good toilet soap, and a nailbrush for the nails. When it is important to have the hands perfectly free from black, as may be the case with a doctor, do not be too violent in the efforts to cleanse the hands thoroughly. It is wonderful how a few hours seem to loosen the dirt. The use of oatmeal has also been recommended as very efficient for cleansing the hands from grease.

According to a French physician, hands soiled by oil and grease when tinkering with motor cars are really not dirty, scientifically speaking of course. The Parisian used his microscope and examined some of the black grease, declaring that it harbored no evil germs. Upon this finding he declares the soiled hands to be "hygienically clean."

Carnot's Ideal Cycle—See Cycle, Carnot's.

Carriage Work—It is only comparatively recently that the body or carriage work of the automobile has received the attention it demands. The purchaser was always interested in the subject; in fact, he was and is sometimes inclined to lay more stress on the body than on the chassis, while the manufacturer, having spread himself on the machinery, had little enthusiasm left for the superstructure. Now, however, automobile body building is quite a special line, and some splendid specimens are turned out.

The first consideration in choosing a body is the number of passengers to be carried. The number should be well within the powers of the engine, and it must be remembered that a large body weighs more than a small one, even when the extra seats are not occupied, and the difference will show itself in increased gasolene consumption and tire wear.

If the car is to be an all-weather vehicle, it should have a good hood or a canopy; and a front glass screen is practically a necessity. The canvas and leather Cape hoods have become

very popular. In any case the hood will have to project a long way forward if it is going to shield the passengers from rain. Side doors to the footboard of the front seat contribute considerably to the comfort of the driver and his companion, though they are comparatively seldom fitted unless specially ordered.

Some ingenious bodies are so constructed as to allow of closed tops being added or removed as required; or to allow of the rear part being detached and a good platform left for the carriage of baggage. Most automobile bodies are sadly lacking in baggage accommodation.

Types of Body.

For some years the tonneau body with rear entrance had a great vogue, but its occupants were compelled to step into the road when alighting from the car and it gradually fell into disfavor.

This objection is overcome in the side entrance bodies which are now the vogue. Many of these at first were none too readily accessible, and some of them involved so long a frame that the cars were very unhandy. This cannot be said of later types which have shown rapid and marked improvement. In fact the development of automobile body building has in recent years kept pace with that of the chassis, and while it cannot be said that either has reached the point of perfection, many modern cars are models of comfort and utility.

The body types in present-day use include many varieties, from the two-seated racing type to commodious and elaborate landaulets, limousines, and buses. Almost every known form of carriage body is now fitted to the automobile chassis and the modern models of most manufacturers are supplied with bodies to suit the needs or the whim of the purchaser. Thus a manufacturer may supply with a certain model of chassis a body of the two-seated runabout, four-seated "tourabout" or five to seven-seated touring-car type.

Body types include the following among other specimens

of carriagework: The racing type with rumble, tonneau with side entrance; two-seated victoria with folding hood, etc.; single and double coupes, partly and completely inclosed; landaulets and phaetons, with various kinds of hoods and canopies; limousines, or closed carriages, in which the front seats are partly open and the rear seats inclosed; limousine landaulets, which can be quickly converted into open carriages and are extremely popular; park victorias, cabs, hansoms, berlins and omnibuses.

Very few autoists, however particular they may be to have in their car everything of the very best, have much knowledge of the difference between good and bad car body work, except in the first appearance of the varnish. They have not in fact had any opportunity of knowing what ingenious developments have been brought into carriage building in relation to the new conditions.

A man has his own ideas about the shape he likes, and he will find that cost varies by 30 per cent on the shape alone. The best way to explain this is to describe a few of the points of a really good motor-car body, and if cheapness is desired it remains within the free discretion of the purchaser to waive what he thinks he can dispense with. In attempting to do this, however, he will be confronted with two facts:

1. That the first-class makers refuse to allow their name to be associated with any body work which does not contain their own irreducible minimum of good points, whether in durability or appearance.

2. That cheapness means adopting a standard pattern which is made in large quantities for the general market without any extra attention to individual peculiarities.

Generally speaking, a touring car for the owner to drive in fine weather requires an open body, glass screen in front, room for baggage on a rack, say at the back, room for spare tires, many tools, head-lamps, very comfortable cushions, light steel or aluminum mudguards, considerable speed and power, and the driving seat with plenty of leg-room.

The particular use to which the car is to be put should invariably be considered when contemplating a purchase.

The question of finish is one for personal determination. Many persons regard very bright colors and a great deal of brass as being in very poor taste. With modern horns they think there is no need for cars to be loud in their get-up. Natural wood finish often looks smart and businesslike without being too showy.

As to the upholstering, leather wears best while some of the substitutes are highly inflammable. The lighter colored materials very soon look soiled. Corduroy wears well, but is rather clinging for the seats.

The mudguards should be of ample dimensions, and should be very strongly mounted, as they are liable to vibrate a great deal; this point hardly receives enough attention. The guards should keep the mud off the car as well as off the occupants; on the other hand, if extended too near the ground, they raise a great deal more dust than necessary.

Style of Seats.

Bucket or armchair seats are now very general in automobiles; but whether bucket or plain, the seat itself should slope down towards the back, the back should slant backwards with a bulge to fit into the small of the occupant's back, and the footboard should be considerably sloped up in front. Beware of armrests that just reach up to the elbow; they are most tiring on a long journey.

Outside cushions for seats are best made smooth and not fitted with buttons, because they are more easily wiped dry and they do not collect pools of water if exposed. Still the absolutely smooth cushion has the drawback that it is slippery. To cure this it is usual to make along the front of such smooth cushion a roll which is slightly raised above the level of the cushion proper. This roll tends to throw the sitter well back into his seat and is quite comfortable.

One of the great comforts which can be obtained in a touring carriage with little expense and practically no addition

of weight is the sliding tonneau seat. The back seat is for this purpose divided into two cushions, and the user will find that by placing his hand under the front of the cushion and pulling the cushion bodily forward it will be released from a catch which holds it back, and will slide into a fresh position about six inches farther forward. This little modification, which is well known in ordinary horse-drawn carriages, gives a change of position which adds very much to the possibility of comfort on a long tour. The same idea could be pushed to a further extreme in the case of an invalid's car by providing that the seat shall slide forward so as almost to bridge over the knee space up to the opposite seat, thereby making a sort of couch.

Width of Doors.

The minimum width of door for comfort is 18 inches at the wide part. The usual width in horse-drawn carriages is about 21 to 22 inches. A really comfortable width is 24 inches, and some automobile makers give considerably more.

Experience shows that a closed car is more difficult to get out of than an open one, chiefly because the person getting out is compelled to stoop forward on leaving the closed car. From this it results that the door must be wider and the step more convenient and easy to get on to with a closed car. The conclusion has been drawn from this that side-chain driven cars are not so suitable for town cars of the closed type as cars driven by a propeller shaft or central chain with live back axle. Here is another point for objecting to combining the functions of a car, for many people would regret to have their field of choice of a touring car restricted so as to exclude the excellent makes which employ side chains.

Chain Guard.

Where a side chain driven chassis is being fitted with a body it is usual to make the sprocket-wheel guard into a step. It is of the utmost importance that this guard should be easily removable either with or without the step that belongs to it, so that the lubrication of the sprocket-wheel bearing, the

flexible joint (which is often introduced into the sprocket shaft) and the chain should be easily got at. It is as well not to forget that if such a car is going touring it may be very useful to change the sprocket wheels; for example, a larger sprocket wheel will be required for fast traveling in a flat country, and the carriage builder in making a sprocket-wheel guard should make allowance for the largest wheel likely to be employed there.

Detachable Body.

In the opinion of many experts the entire carriage work of a car should always be completely detachable from the chassis without disconnecting any single part of the mechanism; that is to say, that no gasolene pipes, lubricating pipes, or electric wires should pass through, be fixed on, or in any way form part of the body. To begin with, this involves that the batteries, if any, shall not be placed in the body, but in a box fastened to the chassis either somewhere near the gear box or outside on the platform step. Furthermore, if the gasolene supply to the float chamber is gravity-fed, which requires the tank to be placed at a higher level than the carbureter (that is to say, as a rule occupying the entire space under the two front seats), the frame of the body must be made to clear this tank, and the tank itself must be fixed to the chassis, so as not to depend upon the body for its support. In this case it is usually impossible for the filling of the tank to be effected except by raising the cushion of the driver's seat. The owner may, of course, be willing to allow the panel at the side of the driver's seat to be pierced so as to allow a detachable filling pipe to protrude through the panel, but this is generally considered to be too unsightly. Certain makers have appreciated the value to the user of the detachable body, and have gone to the trouble of rearranging their design so that this convenience is easily secured. The trouble taken by these makers in the direction of keeping all the gear on the chassis and off the body will be entirely wasted if the carriage work is not kept up to the mark in this respect.

Limousine Top.

An early and popular method of modifying a car for wet weather is to employ a detachable top which fits accurately upon the tonneau. In this case the door window of the detachable top must have its own hinges, and the fitting must be very carefully effected to avoid draughts.

Typical Body Specifications.

The following specifications briefly describe the body of a typical modern American car—Locomobile type E standard.

Material: Selected and thoroughly seasoned wood.

Features: All bodies are ironed for tops. Side doors are wide hinged at the rear, and have special safety locks. New style steps. Rubber mat on the front floor, Wilton carpet in tonneau. Foot rest, adjustable for any desired angle or position; removable. Storage room under the tonneau seat. Brass tire irons. Telescopic brass coat rail. Rubber cloth storm aprons.

Upholstery: Tufted leather, red or black as desired.

Color: Color of both body and chassis is optional, provided painting specifications accompany order. Special notice and extra time required to execute orders for light colors.

Revarnishing Car Bodies.

When a car is used to any extent, it is found that, however good its appearance when first turned out, after a time the paint becomes dull. This is not a serious defect, although it detracts very greatly from the smart appearance of the car. It is a very good plan to have the body-work and frame, together with the wheels, etc., revarnished at least once a year, as it is quite astonishing what an improvement in appearance one or two coats of varnish make; in fact, the car appears practically new again. Owners of cars which have been in use for some time, and who are anxious to dispose of them, might do worse than pay a good carriage painter to revarnish the carriage, as they will realize much more for the car. This tip is not one which is given to enable vendors of secondhand cars

to do dodging work in getting rid of their stock, as, of course, anyone desiring to buy a secondhand car should not be entirely guided by the appearance of it but should certainly have an expert examination, so as to have a report of the condition of the vital parts; but, as before stated, there is no doubt that a pleasing appearance to the eye goes a long way towards influencing the would-be buyer. Those who are accepting delivery of new cars, or old ones which have been done up should test the varnish for dryness by pressing the thumb hard up against some unexposed portion of the body; pressure should be put on the varnish for several seconds, until the heat from the thumb is transferred to the paint. If the thumb comes away from the varnish without any feeling of stickiness, it may be taken to be perfectly dry, but any tendency to stickiness denotes that the varnish is not set, and should, if possible, be given several days more in which to dry. Any dust or dirt which comes in contact with imperfectly set varnish dulls, if it does not spot, the finish.

Washing Car Bodies.

A newly-varnished car should stand for at least a week before being taken into regular use. This is in order to allow the varnish to set properly. Frequent washing with clean cold water and careful drying with chamois leather and exposure to fresh air in the shade will both harden and brighten the finish.

In washing a car, plenty of water should be poured carefully over the parts; it is a mistake to use a swift flowing hose jet. It is better to use a large sponge, well saturating it and squeezing it over the panels of the car body, when the water, in running off, will carry the mud with it. Never allow water to dry on the car, as this is very liable to stain, almost as much so as mud. Hot water and soap should never be applied to any varnished or light-colored painted surfaces. If mud is allowed to remain on the car, it tends to make it very dull, the varnish is spoiled, and what would otherwise appear as a smart turnout will then partake of the nature of a shabby, dilapi-

dated, secondhand affair, not worth nearly the amount which it really is. All the paint work being then dry, or very nearly so, a gloss and polish can be put upon the work by clean, dry cloths and plenty of elbow grease.

When leather upholstery has been wiped perfectly clean, and all dust and damp removed, it can be brought up and made to look like new by liberal rubbing with special preparations for the purpose. Throughout the washing process every care should be taken to avoid water being splashed into the carbureter or the air pipe. The wiring should be kept dry—in fact, this refers to the entire ignition installation, whether it be by storage batteries or by magneto.

Case—A covering, box or sheath for any part of machinery; a casing.

Case-harden—To carbonize the surface of, as iron or mild steel, by moderately heating it in contact with charcoal or charred animal matter in a case or closed box, followed by rapid cooling; to superficially coat with hard steel by any process of cementation.

Case hardening, with yellow prussiate of potash.—The parts to be hardened are first polished, and must be kept free from grease of every description. They are then heated to a dull red, and at this point powdered prussiate of potash is freely sprinkled over the surfaces. The heat is then raised until the potash melts and flows freely and evenly over the parts. It is advisable to add a little potash if the flow is not sufficient. Allow the parts to cool slightly, and then plunge into clean, cold water. Care should be taken when applying the potash to avoid inhaling the fumes given off.

Casing, Outer—The outer covering or shoe of a double-tube tire.

Castellated—Finished or wrought in a style resembling the battlements of a castle; indented at regular intervals, like the embrasures of a battlement.

Castellated Nut—Same as Castle Nut. See Bolts and Nuts.

Caster—A device in a wheel which enables the wheel to

swerve readily to either side. The principle is applied to the steering-wheels of automobiles.

Casting—Any article formed from metal or other material by being poured while in a liquid state into a mold. Many parts of a motor car are made in this way, such as gear boxes, cylinders, base chambers, etc.

Cast Iron—Iron that has been melted and run into a mold to give it the desired form. The process is known as casting or molding.

Castle Nut—See Bolts and Nuts.

Catalysis—A form of chemical action consisting of the decomposition and new combination of elements to produce a given compound.

Catalytic Ignition—See Ignition.

Catch—A term applied to numerous mechanical devices in which one part "catches" on to the other. Thus in some types of low tension magneto an interrupter catch is used which, on its movement in one direction, catches the end of a lever or rod which it misses when returning in the opposite direction. It is a wide term, and capable of being used in many connections.

Cathode—The negative pole of an electric current.

Cation—The element or elements which appear at the negative pole in electrolysis.

Cattle, Driving Past—See under Driving.

Caulk, Calk—To render staunch, as a defective joint; to pack.

This may be done in various ways, according to the nature of the metal in which the fracture occurs, and the pressure which the part has to withstand. In a motor car the parts most liable to have to undergo such repairs are the gasolene and water tanks, the various pipes connected thereto, and the radiators. Leakages in the water tank or pipes can be effectively repaired by packing tow or string soaked in boiled linseed oil, or smeared with white lead, into the frac-

ture, and binding around with string. A leakage in the gasolene tank or pipes is a more difficult thing to deal with, on account of the chemical action of the gasolene. The best method of caulking in this instance is to close the edges of the fracture together by means of a blunt-edged chisel or caulking tool. A leaking cylinder-head can be temporarily made staunch by caulking the joint with red lead, white lead and boiled linseed oil, mixed to a consistency of a thick paste. See Packing.

Causes of Overheating—See under Engines.

Cell—One of the component parts of a complete battery. The cell may be regarded as a unit, of which various numbers are taken to make up batteries. Thus we can have a battery of 2, 4, or any number of cells. See Battery.

Cell, Primary—A single cell of a voltaic battery. See Battery.

Cell, Storage—An accumulator or secondary cell. See Accumulator, Battery.

Cellular Tires—A tire of the solid variety in which the rubber, however, contains numerous cells.

Celluloid—A semi-transparent chemical compound which is highly inflammable. Its nature is tough and elastic, which enables it to withstand rough usage. When subjected to a fairly high temperature by placing in a hot-air chamber, or by immersion in boiling water, it becomes very plastic and can be molded into any shape. It is largely used to make the cases of the battery cells for automobile use, and sometimes as panels in place of glass.

Celluloid accumulator cases, if cracked, can be mended as follows: Clean the cracked part free from grease and dirt, paint it over with a solution of celluloid in amylacetate or acetone. A strengthening strip of celluloid can by the same solution be stuck on over the crack. Acetone takes rather long to dry off, so the parts must be clamped together. Photographers will have plenty of very pure celluloid in very fine strips, in the shape of old roll films or flat films, which

will dissolve well. An imitation of celluloid which is uninflammable is made and appears to offer many advantages over the gun cotton variety, but it cannot be cemented with acetone solution.

Cement—Any substance or composition which is plastic or tenacious according to the degree of heat or moisture. Cements are used for uniting materials of the same or of different kinds; also for forming smooth surfaces, etc. See Glue.

Cement for Iron—See Glue and Cement.

Cement to Join Glass and Metal—See Glue and Cement.

Cement to Stand Acid and Heat—See Glue and Cement.

Center Bit—See Tools.

Center, Dead—In mechanics, that position of the arms of a link-motion in which they coincide with the line of centers when the links are in a straight line, as when the crank and connecting-rod of a steam-engine are in a straight line.

Center of Gravity—The point in a body at which, if the whole mass were concentrated there, the attraction of gravity would remain unchanged.

Center Punch—See Tools.

Centrifugal Blower—A rotary blower or fan which drives a current of air in the desired direction by means of centrifugal force.

Centrifugal Force—The reaction of a body against a force that is causing it to move in a curved path, or its tendency to retain a straight course. This reaction tends to make the body fly off at a tangent. If a stone at the end of a string be whirled round by hand, the string is drawn tight, and a pull is exerted on the hand. This pull is called centrifugal force. The bicyclist in riding round a corner feels the effect of centrifugal force, and his machine leans inward to counteract its influence. The tendency to swing off at a tangent explains why it is so dangerous for an autoist to negotiate a greasy corner at a rapid pace. The car, not having sufficient

Chassis of the Automatic Automobile.

Streator Motor Car—Model "E."

The Brampton Chain.

grip on the surface, slips broadside across the road. Centrifugal force always acts directly on the center of gravity of the object traveling in the curve or circle.

Centrifugal force is made use of in the centrifugal pump, and also in most types of governors. See Pumps and Governor.

Centrifugal Pump—See Pumps.

Centigrade—Graduated into a hundred degrees. Applied to the thermometer used in physics in which the freezing point is 0 and the boiling point 100 degrees.

Centimeter—A measure of length in the metric system. It is the hundredth part of a meter or about .39 of an inch.

Century—Anything consisting of a hundred in number. Thus an automobile or bicycle run of a hundred miles is often called a century.

Chain—In some automobiles a specially made chain is used to transmit power from one point to another, and is generally employed as the intermediary between the jack shaft and the road wheels. Various patterns of chains are made, including those of the block, roller, and twin roller types. Another pattern is the silent automatic pitch chain, in which the links automatically adjust themselves to take up the wear. This differs from the ordinary chain, inasmuch as the wheel teeth do not project through the chain at all, but the links are formed with wedge-shaped ends projecting from the inner face of the chain, which engage with suitable teeth cut on the wheel. As these teeth wear, the wedge enters the tooth to a greater extent, and thus compensates for the slackness that would be otherwise caused. Another advantage of this chain is that it may be made of any strength and width, and its silent running and life render it a particularly desirable drive.

The ordinary block chain consists of a series of suitably shaped steel blocks, which are connected together by side plates.

The roller chain is one in which a roller takes the place

of the block. It is made in various pitches of from ½ inch to 2 inches, and width of ½ to ¾ inch. The breaking loads are greater than in the block type. The roller chain is the one most generally used, on account of its being capable of standing a greater strain and of resisting wear and tear better than the block pattern. The rollers offer less resistance in engaging and disengaging with the chain wheels, for whereas the block is dragged on and off the teeth, the rollers revolve on their hardened bushes.

The twin roller chain has two rollers placed close together, the tooth space intervening between each pair of rollers. This chain runs on chain wheels cut for block chains with the same advantages as the single roller chain.

Care of Naked Chains.

Chains are most efficient agents for the transmission of power, but they require very great care if the best results are to be obtained from them. This necessary extra solicitude which they seldom if ever get is not required with live-axle drive, and is largely responsible for the rapid advance of propeller-shaft transmission in public favor. A chain should always be free and supple, and to preserve it in such condition it is necessary to lubricate it freely when in work and position, to keep it very clean, and to remove all mud, and prevent rust by rubbing with a rag smeared with vaseline or soaked in kerosene.

The best method of lubricating a chain is to dismount it, roll it up upon itself, and place in an open flat pan deep enough to allow of its being covered with melted tallow, the pan being placed over a fire for the purpose of liquefying the lubricant. The chain should be most thoroughly cleaned from all dirt and dry grease in a bath of kerosene before it is simmered in the liquid tallow. Having allowed the chain to stew for some time the pan should be removed from the fire and its contents allowed to cool. When taken from the pan, the superfluous grease only should be wiped off. This method will introduce lubricant between every frictional part

of the chain, and is the only method by which unprotected chains can be made to run satisfactorily, but it will not greatly lengthen their life.

When taking a chain down, the chain ring and the sprocket should all be marked in so distinct a manner that it may be returned right side up, and right side inside.

Adjustment of Chains.

Chains are now obtainable of such strength and durability that, so far as their life is concerned, they leave little to be desired, and as this method of transmission is so frequently preferred to that of the live axle for many cars of the heavier class, it is reasonable to ask whether some of their obvious disadvantages could not be easily eliminated.

Some method of adjusting the distance between sprockets and driving wheels is invariably provided, but it frequently happens that its limit is reached long before the chains are worn to a degree rendering renewal advisable. Or again, a change of gear by substituting different sprockets (one of the great advantages of the chain drive) frequently leaves the chain either too long or too short by a link or more, apart from the range of adjustment available.

The removal or addition of a link is an undertaking requiring a certain degree of skill, apart from the question of time, in the case of the majority of chains, which are built up of specially hardened materials.

It seems desirable, therefore, that provision should be made in all chains for one, two, or more links to be easily removable at will, without the necessity of resorting to the workshop. Several of the end links could be furnished with bolts similar to those invariably used for joining up the two ends.

To provide for lengthening their chains, automobilists would then only have to carry a few spare links (which should be supplied as a matter of course with every chain), and, whether necessitated by wear, stretch, or what not, the removal of one or more of the end links need only be a matter of minutes.

It could scarcely be urged that increasing the number of removable bolts from one to two or three would decrease the strength of the chain. The most serious objection would be their projecting heads and nuts, whilst the smallest of pins outside the lock-nut practically eliminates any risk of their coming off. In bicycle practice a nut alone is invariably used without a pin, and accidents through the bolts coming out are rarely heard of.

When adjusting driving chains, care should be exercised that a sufficient amount of play should be allowed to the carriage spring links. If the rear axle is carried too far backwards in adjusting the chain, the length of the movement to the spring links is curtailed and their free action interfered with to a large extent. Adjustments carried to this length will result in no action being allowed the links. The comfort of the car will be diminished to a very noticeable degree, which may be looked for without result if the point above raised is not thought of. When the links incline noticeably rearwards, take a link out of the chain and so save trouble.

The Brampton Chain.

The "Brampton" chain, shown on another page, is made of what is called self-hardening steel. These chains are fitted with a connecting link, having one side-plate threaded and fitted with bolt and nut. In some cases where there is little clearance on the car this connecting link is too wide, and in such case the nut can be discarded and the end of the bolt cut off and bored for a cotter pin fastening. This makes the same style of connecting link as generally used by American chain makers.

In placing the chain on the car, care should be taken to see that there are no interferences from chain guards, gear case housing, etc.

Chain Adjustment—The tension of driving chains must be kept so that when stationary there is just the least sign of slack in either the top or bottom side of the loop. When making the adjustment care must be taken to screw out the

turnbuckles on the radius rods equally on both sides of the car, so as to keep the chains equally taut, the back wheels in alignment with the car, and the back and front sprockets in alignment with one another.

Always carry at least one spare link for each chain, preferably also the special or nutted link which is easiest to open and put in place.

Chain Broken—See Miscellaneous Roadside Repairs.

Chain-case—A metallic covering for a driving-chain.

Chain Drive—The method of transmitting the power by means of chains either from the jackshaft to the road wheels, or from the engine direct to a live axle, as in the case of steam cars. See Transmission, Change Speed Gear.

Chain Gearing—See Gear, Gearing.

Chain Guard—See under Carriage Work.

Chain Link—The side plates connecting the pins on which the rollers of a roller chain revolve, or connecting the blocks of a block chain.

Chain Ring—See Wheels.

Chain Rivet—The pins connecting the side plates of a chain and on which the rollers or blocks oscillate.

Chain, Sprocket—A chain devised to transmit power from a sprocket wheel.

Chain-wheel—See Wheels.

Chains, Adjustment of—See under Chain above.

Chair—A block of iron or other material forming a kind of clutch to support a weight or another part of machinery.

Chalk, French—A variety of indurated talc of a pearly-white or grayish color; used in powdered form on inner tire tubes to overcome stickiness.

Chamber—The term chamber applied to motors may refer to the crank chamber, the combustion chamber, or the valve chamber, though it is usual to specially define the chamber referred to.

The crank or base chamber is either an aluminum or an iron casting which contains the bearings for the crank-shaft and the shaft itself, and in some cases the gear for operating the valves. Also known as the crank case. See Internal Combustion Engine.

The combustion chamber is the space over the piston when this is at its highest point in the cylinder. Into this space the charge is compressed by the upward stroke of the piston, previous to being ignited by the electric spark, to cause the working stroke. See Internal Combustion Engine.

The valve chamber is practically a continuation of the combustion chamber projecting from its side, and into it the inlet and exhaust valves open.

Chamber, Crank—See Chamber.

Chamber, Float—In a carbureter the cavity which contains the float.

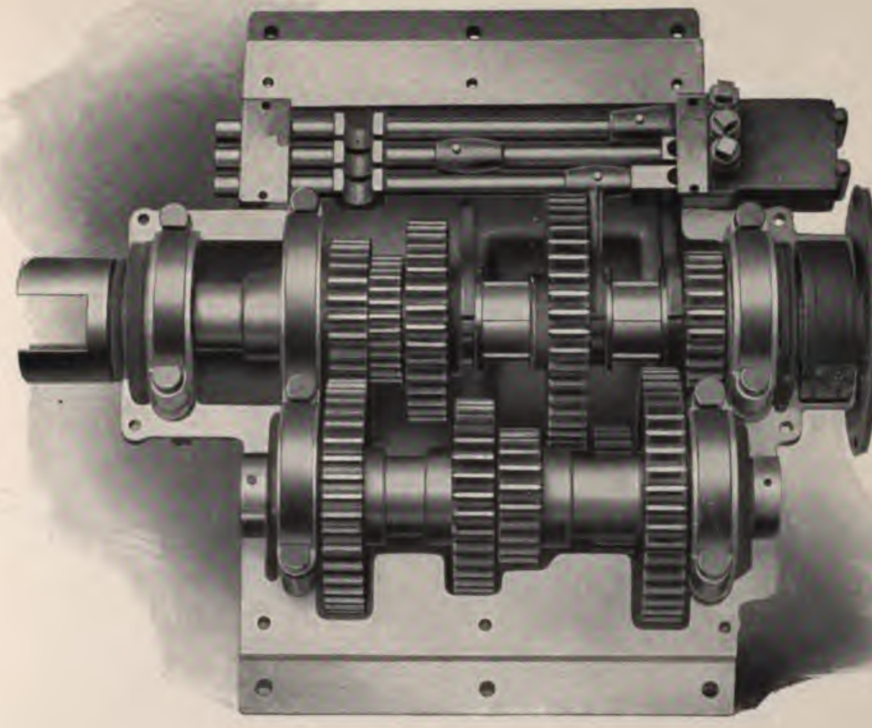
Chamber, Mixing—The portion of a carbureter in which the explosive "mixture" is formed.

Chamfered—Any piece having its angles or edges blunted by cutting square across the plane which bisects the angle is spoken of as being "chamfered." Instance, the sharp corners of a square post. Used generally only in connection with wood or body work.

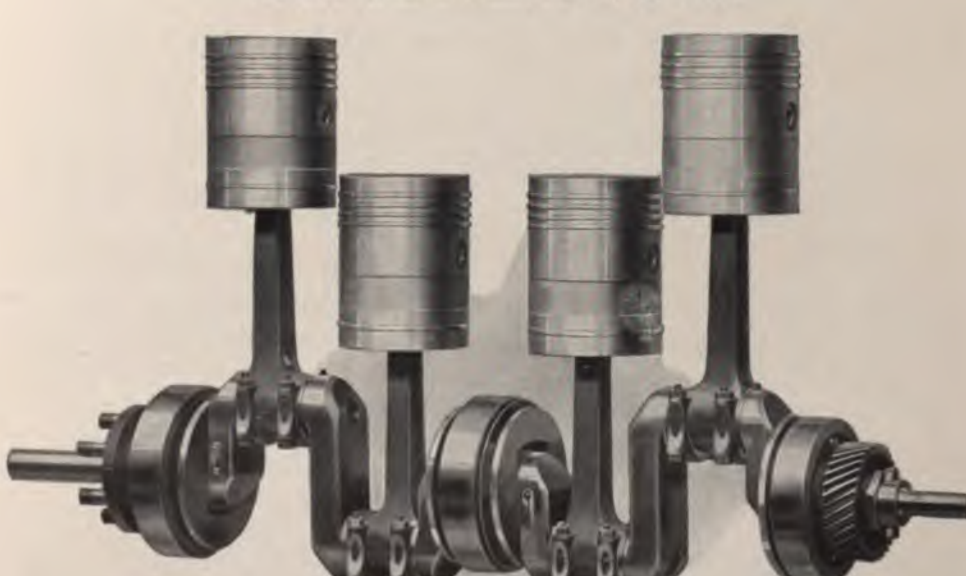
Chamois Skin or Leather—A kind of soft leather first prepared from the skin of the chamois antelope; now made from various other skins dressed with fish-oil.

Change Speed Gear—A system of gear-wheels designed to secure variable speeds of an automobile while the motor runs at a uniform rate. The largest cars generally have four forward speeds and smaller ones three, or sometimes only two. The means for varying the gear ratios between the engine and the driving wheels also provide for making a break in the transmission gear, and generally, to some extent, for reducing the ratio as a whole. The reversing gear is, as a rule, combined with the variable speed gear.

The varying conditions of the road work encountered by



Selective Transmission—The Car De Luxe.



Crank Shaft—The Car De Luxe.

an automobile, and the peculiarities of the gasolene motor, demand the use of some method by which the speed and power of the car can be varied at the will of the driver to suit the conditions at any particular time.

The internal combustion engine exerts its maximum power at a constant speed; consequently, variation of pace is possible only between narrow limits from the motor itself, and recourse has to be had to the mechanism known as the change speed gear, in order to obtain the necessary range of flexibility required.

This consists fundamentally of a reducing gear, by which the high rate of revolution of the motor crank shaft is modified to a lower speed on a secondary shaft, from which the road wheels are driven. The ratio between the rate of revolution of the motor shaft and the speed of the secondary shaft is capable of alteration, generally in a series of steps and between fixed limits.

The various types of mechanism by which this has been accomplished are very numerous. Before proceeding to study them, it is advisable that the reader should have some idea of what a motor car is, and he should therefore first turn to "Motor Car," and carefully peruse the description under that heading.

Ordinary change speed gear, such as is in every-day use at present, consists generally of a series of gear wheels varying in size, pairs of which can be engaged one with another whilst the remainder are idle. The mechanical methods by which this can be done are limited in number, and the following list indicates the broad headings under which change-speed gear principles act:

1. By sliding the wheels into or out of mesh, either separately or on a sleeve.

2. By having the gears constantly in mesh, and determining the working pair by means of a sliding feather, which locks any required wheels to the shaft.

3. Constantly meshing gears rendered live by means of

clutches, either frictional or expanding, or by positive or dog clutch engagements.

4. Epicycloidal gears, where the changes are obtained by gripping and releasing the various members.

These four classes comprise the standard systems, but almost every maker of note has some specialty of his own, which, though varying but slightly from a standard pattern, would necessitate a lengthy description for its complete comprehension.

The first of these four classes of change speed gear is found in the Panhard and other chain-driven cars, is typical and comprises simply a pair of shafts inclosed in an air-tight box, one driven through the medium of the friction clutch from the engine, and the other driven from the first by means of gear wheels.

The most satisfactory arrangement of variable speed mechanism comprises a motor powerful enough to take all small gradients on the top gear, combined with a transmission providing at least two lower gears for hills properly so-called.

TRANSMISSION AND VARIABLE GEARING.

Selective Sliding Gears.

The method of sliding gear wheels into mesh with each other endways seems, from an engineering point of view, a barbarous system. It is remarkable, however, that in practice it has been proved most successful for change speed gears in motor cars. The different ways in which this method of gear changing can be arranged is remarkable, and we shall deal with several systems in order.

The Panhard Type—The Panhard was the earliest example of the type of change speed gear in which the gear wheels were arranged to slide endways. It is still used on a number of cars, and has given remarkable results, but modifications of it have lately been introduced which are becoming rather more popular, though the principle embodied in the Panhard gear is that which is found in practically every type of sliding gear on the market.

In the accompanying figures, which are purely diagrammatic, we have a four-speed Panhard type of gear.

The different figures from one to four show the gear in operation in four different speeds; as the reference letters are alike in the four diagrams, there will be no difficulty in following the procedure.

Shaft X is the shaft which is driven by the engine. It will be noticed that it is carried in two bearings—one at each end in the gear box, and that between those two bearings the shaft is square shape.

It is on the squared part of the shaft that the four wheels A, B, C, and D are mounted. They are so mounted that

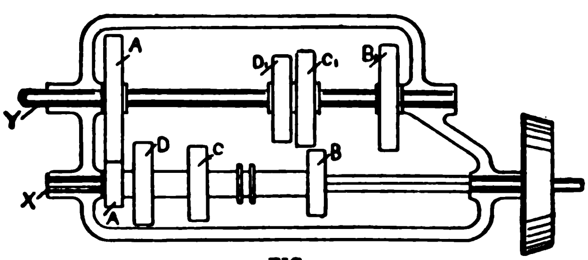


FIG. 1.

A, A1, Low speed wheels.
B, B1, Second speed wheels.
C, C1, Third speed wheels.
D, D1, Top speed wheels.
X, Primary Shaft.
Y, Secondary shaft.

they can slide on the square, being pushed along in either direction by a fork which encircles the collar shown between B and C. The fork which operates this collar is connected by means of rods to the change speed gear lever operated by the driver.

It must be remembered that A, B, C, and D are always relatively in the same position to each other, because they are mounted on one single sleeve which slides along the squared part of the shaft X, so that any movement of the collar in either direction will move the whole four gear wheels.

Outside of the gear box is seen, in diagrammatic form, the male portion of the clutch which puts shaft X into driving communication with the engine shaft. X is termed the

primary gear shaft. Lying parallel with it, and also in two bearings in the gear box, is shaft Y, which is termed the secondary shaft. It is from shaft Y that power is transmitted to the differential box. On Y are wheels A1, C1, B1, and D1. These wheels are of such diameters as to mesh respectively with A, B, C, and D on the shaft X. They are rigidly attached to the shaft Y, and can neither move around nor along it. In this respect they are different from the wheels A, B, C, and D on shaft X. These wheels cannot move around the shaft, but can move along it. In the position shown in Fig. 1 the gear wheel A is in mesh with gear wheel A1.

If, now, the engine drives the shaft X, the wheel A will

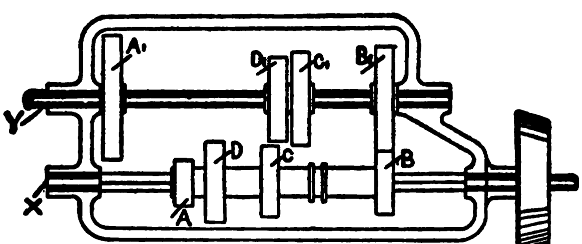


FIG. 2.—POSITION ON SECOND SPEED.

rotate shaft Y through the medium of A1, and Y will rotate the differential box and drive the car; but since A is considerably less in diameter than A1, it is obvious that the car will travel comparatively slowly relatively to the speed of the engine shaft, which is the speed of X. This is the low gear.

Supposing, now, it is desired to make the difference between the speed of the engine and the speed of the shaft Y relatively less; if we bring the sleeve carrying wheels A, D, C, and B to the right in our diagram, the wheel A will come out of mesh with A1, and B will come into mesh with B1. B1 is smaller in diameter than A1, while B is larger in diameter than A; therefore, although B is smaller than B1, shaft Y will still rotate at less speed than shaft X. This will give us the second speed. This is shown in Fig. 2.

To get on the third speed we must slide the sleeve on shaft X still further to the right until B comes out of engagement with B1, and C comes into engagement with C1. This is shown in Fig. 3. It will be seen here also that C1 is larger in diameter than C, so that shaft Y will still be mov-

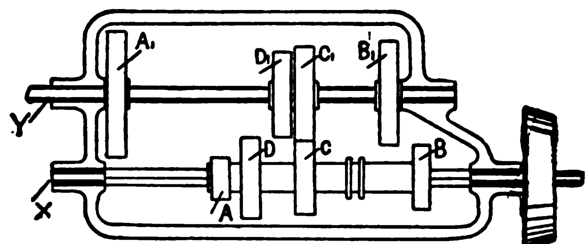


FIG. 3.—POSITION ON THIRD SPEED.

ing at a less speed than shaft X, but there will not be so great a difference as in the case of Fig. 2.

To get on to top gear, the sleeve on shaft X must be moved still further to the right until D and D1 come into engagement with each other. Now, D and D1 are of the same diameter, therefore shaft X and shaft Y will be rotating at the same speed, and the engine will be driving the bevel pinion on the differential at its own speed.

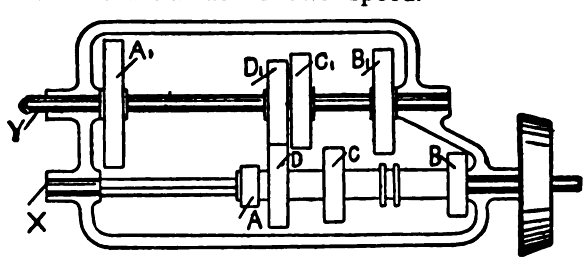


FIG. 4.—POSITION ON TOP SPEED.

In this method of arranging the sliding gears there can never be a position in which the engine drives direct on to the shaft which drives the differential. That is to say, there is no direct drive on the Panhard type of gear.

As regards the reverse—which is not shown in our diagram—there is a wheel mounted on a third shaft which en-

gages with A1 and A respectively—thus reversing the direction of motion—shafts X and Y now revolving in the same instead of the opposite direction to each other. This gives the reverse gear.

In the Panhard system (as used up till very lately on all models of Panhard cars, and which has given its name to a type of gear) it is usual to have a countershaft with sprocket wheels and chain drive, and in such cases the secondary shaft Y carries on its end, and inside the gear box, the bevel pinion which engages with the crown wheel on the differential shaft. The same system is adopted on other cars in which the shaft Y terminates in a universal joint, connecting it up to either a cardan or a propeller shaft, and transmitting the power to a live axle which contains the differential.

The Mercedes Type—The Mercedes type of gear takes its name from a gear which was introduced on one of the earlier Mercedes cars. The word "Mercedes" has now become a generic term for gears which incorporate the system introduced by the Mercedes Company. It uses the sliding type of gear—the gears coming into engagement with each other endways—but it has this great advantage, that, by using two pairs of sliding wheels instead of all four sliding together, as in the Panhard type, the shaft on which the gear wheels are mounted can be kept short. It has also another distinct advantage in the fact that a direct drive from engine to back axle can be got without the power having to be transmitted through the second shaft. In such cases, of course, instead of having two sets of gears in operation, only one set is used between the engine and the back axle on the top speed —that set is the bevel and crown wheel of the differential.

The gear box of the 35 h.p. Talbot car, shown in Fig. 5, may be taken as an example of the latest type of the Mercedes principle.

It will here be seen that we have a primary and a secondary shaft, just as we have in the case of the Panhard. The primary shaft is shown at PGS, the secondary shaft at SGS. Sometimes SGS is known as the lay shaft. The pri-

mary gear shaft is not directly connected to the engine or the clutch, but at the left-hand end in our illustration it will be seen that it is surrounded by the sleeve IGS, which we may term the initial gear sleeve. This sleeve is driven by the engine, and, with the gears in the position shown in our illustration, it is not in connection at all with the primary gear shaft PGS, but will simply revolve about it on the ball

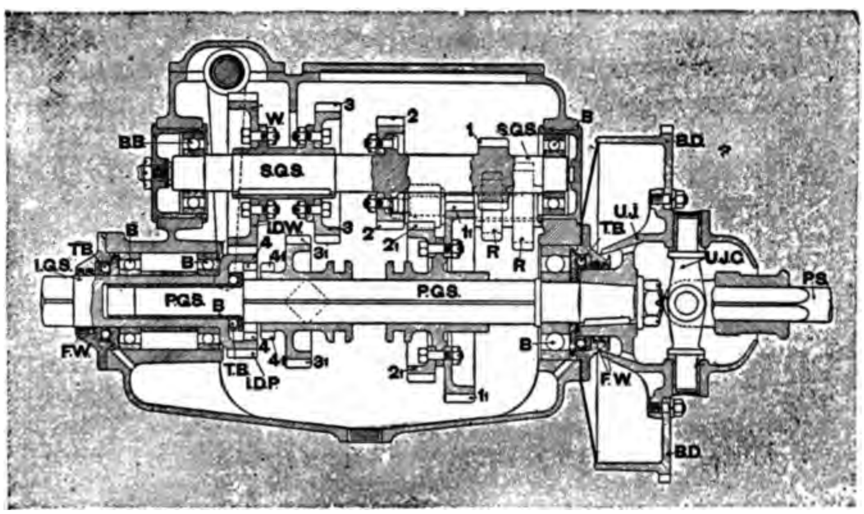


FIG. 5. -VERTICAL SECTION OF TALBOT GEAR BOX.

I G S, Initial gear sleeve.
I D P, Intermediate driving pinion.
I D W, Intermediate driven wheel.
S G S, Secondary gear shaft.
1 and 1₁, Driving and driven wheels of first speed
2 and 2₁, Driving and driven wheels of second speed
3 and 3₁, Driving and driven wheels of third speed.
4 and 4₁, Driving and driven parts of fourth speed direct driving clutch.
P G S, Primary gear shaft.
R R, Reverse pinions.
B B, Ball bearings.
T B, Thrust ball bearings.
F W, Felt oil-retaining washers.
U J, Fore part of universal joint.
B D, Brake drum.
U J C, Universal joint coupling.
P S, Propeller shaft.

bearings B B. The power from the engine is transmitted to this sleeve. On its right-hand end it is provided with external and internal teeth, the external teeth being explained by the letters IDP (which stand for intermediate driving pinion). Now, this pinion is in constant engagement with the gear wheel IDW (which stands for intermediate driven wheel) on the secondary gear shaft SGS; that is to say, so

long as the engine rotates the sleeve 1GS, it will also rotate the gear wheel IDW, and, therefore, the secondary gear shaft SGS and all the wheels upon it—all these four wheels being permanently fixed in position and incapable of rotating except with the shaft.

Imagine, now, the gear in the position we show it and the engine running. IGS is rotating and driving with it at a much lesser speed the shaft SGS, because the pinion IDP is less in diameter than the gear wheel IDW.

It will be seen that no gear wheels on the shaft SGS are in gear with the shaft PGS, so that the shaft PGS will not be rotated by the engine, and as this shaft is connected by the universal joint UJC to the propeller shaft of the rear axle PS, the engine will not be driving the car.

On the primary gear shaft PGS are two sets of gear wheels. On the right are gear wheels 1_1 and 2_1, which can be slid independently along the gear shaft because they are on a square which, while preventing them rotating, allows them to slide laterally along it. Then we have the gear wheels 3_1 and 4_1 on a similar sleeve, capable of sliding along the shaft, but not rotating upon it.

In order to allow the engine to drive the shaft PGS, and in view of the fact that the shaft SGS is constantly rotating while the engine is running, it is necessary to slide some one or other of the wheels on shaft PGS into engagement with one or other of the wheels on shaft SGS.

It will be obvious that the smallest wheel on shaft SGS, if put into engagement with the largest wheel on shaft PGS, will give us the greatest difference between the speed of the two shafts, and, therefore, the greatest difference between the speed of the engine and the speed of the propeller shaft which drives the car.

Hence, by moving the sleeve which carries 1_1 and 2_1 so that the wheel 1_1 comes into engagement with wheel 1, we get the first, or lowest, speed—the power being transmitted through IDP, IDW, 1 and 1_1 to the shaft PGS and the propeller shaft PS.

If the sleeve is moved to the left, so that 2_1 comes into engagement with 2, we still have a smaller wheel on shaft SGS in gear with a larger wheel on shaft PGS; but the difference is less, and, therefore, the difference between the speed of the engine and the speed of the car will be reduced. This is the second speed, the power being transmitted through IDP, IDW, 2 and 2_1 to shaft PGS.

For forward speeds these are the only two functions which are performed by the sleeve carrying the two wheels 2_1 and 1_1.

If it is desired to get from the second to the third speed, the sleeve carrying 2_1 and 1_1 must be returned to a position in which neither of the wheels engage with their corresponding wheels on the secondary gear shaft. The gate mechanism, which we shall shortly explain, allows us to do this, and to leave that pair of wheels locked in the neutral position. The next movement of the hand-lever brings the wheel 3_1 on its sleeve to the right, so that it gears with 3 on the secondary gear shaft. The engine will then drive through IDP, IDW, 3 and 3_1, thus rotating the primary gear shaft PGS—still driving the car at a reduced speed compared with that of the engine. This is the third speed.

For the fourth speed, in which the engine will drive the propeller shaft at the same speed at which it is turning itself, we must move the sleeve carrying wheel 3_1 and 4_1 to the left. 4_1 is not really a gear wheel, although it is exactly the same shape as a gear wheel, but it meshes completely into all the teeth of the internal wheel 4, forming a clutch between the primary gear shaft and the initial gear sleeve. The engine, as before, will rotate the intermediate gear sleeve IGS, and as 4_1 is completely housed in 4, the primary gear shaft PGS and the initial gear sleeve IGS driven by the engine become as one, and rotate at the same speed; meanwhile, the secondary gear shaft rotates idly, having no effect on the transmission of the power.

As regards the reverse, there are two wheels R and R shown in faint outline. These wheels are mounted on a sep-

arate shaft underneath the primary and the secondary gear shafts. By moving these two wheels R and R to the left, wheel R will come into engagement with wheel 1 on the secondary gear shaft, while the lesser wheel R will come into engagement with wheel 1 on the primary gear shaft, thus reversing the motion, and making the primary gear shaft rotate in the opposite direction to the initial gear sleeve driven by the engine. This gives the reverse gear.

It will be seen that in this gear the secondary gear shaft, with all its wheels, is constantly rotating even when the gear is so arranged that there is a direct drive on top gear. Several gears on the Mercedes principle have been devised to overcome this difficulty and to put the secondary gear shaft entirely out of operation while the high speed gear is in operation.

Gate Control Mechanism.

In those types of gear which, on the Mercedes principle, as we have described, use two pairs of sliding wheels instead of only one set of sliding wheels, as in the Panhard, a gate control mechanism is usually adopted. It will be seen that it is necessary that two of the speeds utilize one pair of sliding wheels to slide into engagement with one or other of two wheels, and that the other two speeds use the other pair of sliding wheels. This could be achieved by adopting two operating hand levers, one for each pair of sliding gears; but this would be a disadvantage in that it might confuse the driver at a critical moment, and he might, unless some intricate form of interlocking arrangement were fitted, accidentally put two gears into mesh at the same time. In any case, it would compel him to move one lever to disengage one set of gears, and then move another lever to engage another set.

In order to overcome this difficulty, a gate change and selector bar arrangement is usually applied. These appliances may be designed in different ways, but the principle underlying them all is that which is illustrated, in a purely diagrammatic form, in Fig. 6. A is the change speed lever

on the end of the shaft F, which is free to oscillate in a sleeve G, or any bearing equivalent to the sleeve G, which is attached to some part of the car. It is also free to move endways inside the sleeve G. The extent of its oscillation in G is determined by the length of the slots in quadrant B, through which the lever passes. It will be seen that the quadrant B has two slots C and D, with a gate between them E. Now, the lever can only pass through from one slot to the other when it is in a position opposite to E, so that the combined

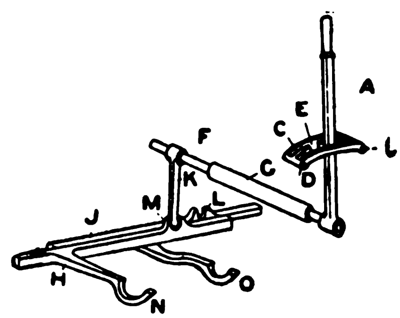


FIG. 6.—DIAGRAMMATIC VIEW OF A SELECTOR BAR AND GATE CONTROL MECHANISM.

A, Change speed lever.
B, Quadrant through which lever A moves.
C and D, Slots in the quadrant through which the lever moves.
E, Gate or opening between the two slots in quadrant B.
F, Oscillating shaft to which levers A and K are rigidly attached.
G, Sleeve through which shaft F may be moved endways and in which it may be oscillated.
H, One of the selector bars.
J, The other selector bar.
K, Selector lever operating bars H and J.
L, Slot in selector bar J.
M, Slot in selector bar H.
N and O, Forks on the selector bars H and J which engage with the sliding wheels in the gear box.

width of the two slots determines the distance of travel of which the shaft F is capable inside the sleeve G.

At the other end of shaft F is seen a lever K, which is rigidly attached to it, and this lever K not only oscillates with the oscillation of the shaft F, but is also moved endways with F. H and J are two bars which are free to slide endways in guides, which, for the sake of clearness, are not shown in our diagram. These bars have projecting from them slotted lugs L and M. These slotted lugs are of such a shape that the end of the lever K can be moved into them

endways, and will engage with them in such a way that they can be moved lengthways by any movement of the lever K. These bars are known as "selector bars," and the lever K as the "selector lever." It is the function of lever K to select and operate the gear wheels which it is required to move.

The bar H has, formed with it, an arm having at its end a fork N. This fork engages with a collar on one pair of sliding wheels in the gear box. Similarly, the bar J has an arm terminating in a fork O, which engages with the collar on the other pair of sliding gears in the gear box. In the position shown the gear change lever A is in the forward slot in the quadrant, so that the lever K is in engagement with the slot in the bar H. By moving the lever backward and forward in the slot D in the quadrant, the bar H will be moved backward and forward, and will, of course, carry with it, through the medium of the fork N, one pair of gear wheels. When lever A is in the forward position in the slot D, one of these gear wheels will be in engagement with a gear wheel on the secondary shaft. Similarly, when it is moved to the left-hand end of the slot, it will cause the other wheel of the pair to engage with another wheel on the secondary shaft. It will be seen that this will give two different gears.

When lever A is moved into such a position that it comes opposite the gate E between the two slots C and D, this particular pair of wheels which the bar H controls will be in a position in which they are out of engagement with their fellow-wheels on the secondary shaft. When in that position; the slot M in bar H will come opposite the slot L in bar J. If, now, the lever is pushed through the gate E into the slot C, the lever K will similarly be pushed through out of slot M in bar H into slot L in bar J. Bar H will then be left in the same position in which bar J is in our illustration, and the operation of the hand lever A will only control the bar J; that is to say, the lever has been made to select another bar in place of bar H. If, now, the lever is operated as before (but, of course, in this case in slot C of the quadrant),

bar L will be moved backward and forward, and, through the medium of the fork O attached to it, it will move the second pair of sliding wheels. When in the forward position, it will engage one wheel with its fellow on the secondary shaft. When it is in the backward position, it will engage the other wheel of the pair with its fellow on the secondary shaft. In order that while one bar is being operated and the other lies idle the second one cannot be moved so as to engage the other pair of wheels, spring tops are usually provided which hold the bar not in operation so that it cannot move endways, so as to prevent two gears being put into operation at the same time, which, of course, would be disastrous.

To make our diagram as simple as possible, we have left out the arrangement for the reverse, but this consists of a third slot in the quadrant parallel with the slots C and D, and also having a gate similar to E through which the hand lever can be pushed. It can easily be imagined that lever K will then be carried past the slot in the bar L into a slot in a third bar which operates the gear wheel which gives the reverse motion.

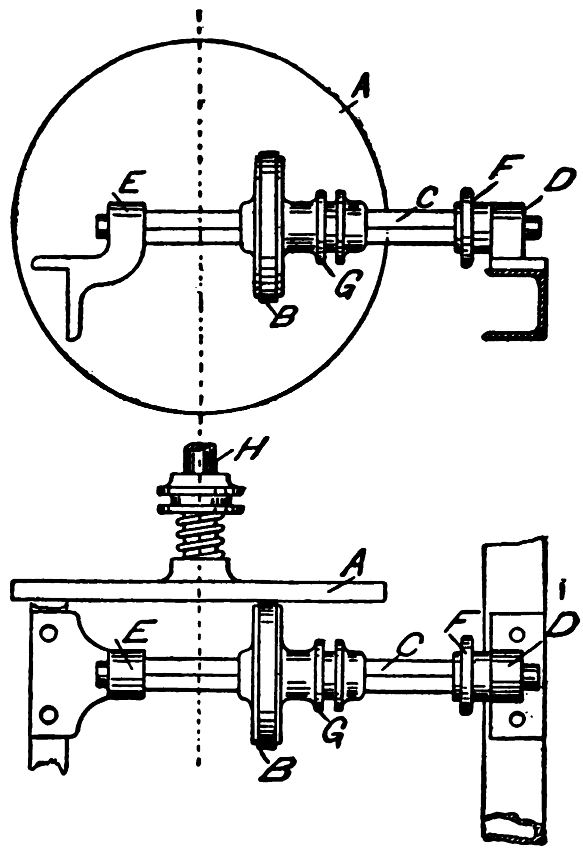
It will be understood that the action of this device is such that the lever cannot be moved from one slot to the other without leaving the bar, with which it formerly engaged, in the neutral position, and the wheels consequently out of gear.

This selector bar arrangement is carried out in different ways on different cars. Sometimes the whole arrangement is incorporated in the gear box; in other cases the selector bars and the selector lever are arranged in a separate case, and the rods are extended from this case to the gear box.

Friction Gearing.

Many attempts have been made to get a variable gear for motor cars which would give an infinite variation between maximum and minimum, and this has generally been done by adopting some sort of friction drive. The friction of the periphery of one wheel on the face of another, and sliding

the one wheel across the other, has been utilized on many occasions. In its simplest form this gear is shown in Figs. 7 and 8. Fig. 7 represents it in plan and Fig. 8 in elevation.



FIGS. 7 AND 8.—A SIMPLE FRICTION CHANGE SPEED GEAR.
A, Flat faced wheel driven by engine.
B, Friction wheel sliding across face A.
C, Shaft which carries friction wheel B.
D and E, Bearings carrying shaft C.
F, Chain sprocket to transmit power.
G, Collar for moving wheel B.
H, Collar and spring pressing wheel A up against wheel B.

In both figures A represents a large wheel with a flat face, driven by the engine. B represents a wheel having on its periphery a leather friction surface, which comes in contact

with the wheel A—best shown in the plain view, Fig. 7. B is mounted on a shaft C, and this shaft is carried in bearings D and E, and at one end a chain wheel F is keyed to it, by means of which the power is transmitted to the differential. B is capable of sliding along the shaft C, which at that part is square, but not of rotating upon it. It is slid along the shaft by means of the collar G. H is a coil spring which presses the engine-driven wheel A up against the friction wheel B.

By moving B along the face of A, different ratios of gearing between the shaft which carries A and the shaft which carries B may be obtained, and, therefore, different ratios between the engine and the road wheels. If the friction wheel B is moved right across the center of the wheel A to the opposite side, it is obvious that it will be driven in a reverse direction, which gives the reverse gear. A lever is used to operate the sliding wheel B, and another lever is used to take off the pressure of the spring H so as to release frictional pressure between A and B, thus acting as a clutch. The pressure may be taken off when changing the gear, though in this type of gear it is not always necessary. Our diagrams show only a very simple arrangement of this kind of change speed gear, but, however carried out in practice, the principle remains the same.

Chain Drive Gearing.

There are two principal systems of transmission, known respectively as the chain drive and the gear drive. In the former the crankshaft of the motor is arranged lengthwise of the car, the variable speed gear box comes behind the clutch, and motion is communicated to a transverse, balance-geared shaft, the ends of which are connected by chain gearing with the respective driving road wheels. The greater part of the clutchshaft is of square section, and on this part is mounted a sleeve furnished with four spur wheels of different diameters. Another shaft, called the gearshaft, is set parallel to the clutchshaft and has fixed to it four spur wheels,

proportioned to those on the sleeve. The sleeve can be moved lengthwise, by a hand lever, so as to bring any one wheel thereon into engagement with the fellow wheel on the gearshaft. The different wheels in each set are so spaced apart that it is impossible to engage two pairs of wheels at the same time. So in changing from one gear to another the parts pass through an "out of gear" position; and this is how they must be set for starting the motor, and also for allowing the motor to run while the car is making a temporary stop. Otherwise it would be necessary to hold the clutch out of engagement all the while the car was stopped and the engine running.

The average size of the wheels on the sleeve is less than the average size of the wheels on the gearshaft, so that, as a rule, part of the gear reduction between the motor and the road wheels is made here. When the largest wheel on the sleeve is meshed with the smallest wheel on the gearshaft the car will be driven at its highest (in this case the fourth) speed. And as each smaller gear wheel on the sleeve is meshed with its fellow on the gearshaft, the gear will be reduced, through the third and second speeds to the first speed, in turn. The "first" speed means the lowest in automobiling. On the rear end of the gearshaft is a bevel wheel which gears with a corresponding bevel wheel on the balance-geared countershaft.

The Reverse Motion.

The reverse motion in a chain drive gear is often obtained by bringing a third wheel or pinion into gear with a wheel on the sleeve and a wheel on the gearshaft, these two wheels being of such sizes that they cannot mesh directly with each other. The introduction of the pinion, of course, causes the sleeve and the gearshaft to turn in the same direction; while, when the other wheels thereon engage directly with each other, they turn in opposite directions. The later form of reversing gear only provides one backward speed, and this should be a slow one; indeed, it is best to make it a lower gear than any of the forward ones, as then if a hill is en-

countered that even the first forward speed is too high for, the car can sometimes be driven up backward. The old form of reversing gear gave as many speeds backward as forward, and most, if not all, of them were too high for ordinary use. The driver who accidentally reversed on his fourth speed had quite an exciting time of it.

The Side Chains.

The outer ends of the balance-geared cross-shaft or countershaft are generally separate from and coupled up to the main portions by flexible joints. A chain wheel or sprocket is fixed to each of these end pieces, and corresponding chain wheels are mounted on the driving road wheels, which turn freely on a fixed axle. Endless pitch chains run round the pairs of chain wheels. Adjustable "radius rods" are provided for keeping the wheels of each chain at a fixed distance apart, notwithstanding the movement of the carriage springs; and these rods also provide means for adjusting the tension of the chains. The chains being so close to the road wheels were very much exposed to wet, dirt and grit, and consequently often wore out quickly, but in modern cars they are satisfactorily incased. A further reduction of the speed ratio is made in the chain gearing, the sprockets on the countershaft being smaller than those on the road wheels.

The original chain drive gear being very bulky, attempts have been made to modify it so as to reduce the size. One of the most successful consists in dividing the sleeve into two parts. This allows the spacing apart of the wheels to be reduced, and also enables the gear to be changed from one speed to another without passing through the intermediate gears.

Another device consists in packing the wheels in each set close together and arranging the respective pairs in permanent engagement. All the wheels on one of the shafts are normally loose, and each is fixed as required by a rod carrying a key or feather sliding in the shaft. This is very compact, and it gets over the sliding of the wheels into mesh

with one another, but the strains on the key and keyways are very severe, though removed from the teeth.

The chain drive type of gearing is seldom found except on the larger cars and those of the buggy type.

The Gear Drive.

The cardan, arbor, propeller-shaft or live-axle gear is common on light cars and has made very rapid headway on the heavy ones. The arrangement of the motor and clutch is similar to that described above, but the variable speed gear is devised with the clutchshaft and gearshaft in line; and for the top speed these two shafts are coupled together and rotate as one, the power being transmitted direct instead of through spur wheels. There are at least three speeds forward and one reverse, the two lower speeds and the reverse being obtained by the spur wheels. The construction is very ingenious, and may be described thus: The rear end of the clutchshaft and the forward end of the gearshaft telescope into each other. The gearshaft is made of square section, and on it is mounted a sleeve carrying two spur wheels of different sizes. On the forward end of the sleeve are two strong dogs or projections, while on the rear end of the clutchshaft is fixed a wide spur pinion having two recesses in its back face. A second gearshaft is mounted parallel to the first, and on this are fixed three forward spur wheels corresponding in diameter to the two on the first gearshaft and the one on the clutchshaft.

For the top speed the clutchshaft and first gearshaft are coupled together by moving the sleeve forward until the dogs thereon enter the recesses in the spur wheel on the clutchshaft. This is the "direct drive," and is so called because no power is lost by transmitting it through the second gearshaft; indeed, in some forms of the gear, the second shaft is not even rotated when the top speed is in. For the two lower speeds, the sleeve is moved back so as to disengage the dog clutch and bring one of the wheels on the sleeve into gear with the fellow wheel on the second shaft. Now

the power is transmitted from the pinion on the clutchshaft to the largest wheel of the second shaft, and then back from one of the smaller wheels on this shaft to the wheel in gear with it on the sleeve, and so to the first gearshaft. This is not unlike the backgear of a lathe. For reversing purposes a fourth wheel on the second shaft is geared with the larger wheel on the sleeve through an intermediate wheel.

This form of variable gear is now often employed in conjunction with a balance geared cross-shaft and side-chains. On powerful cars it is not infrequently modified to give four speeds, and then the third speed is sometimes made to give the direct drive, if the fourth is too high for general use.

In nearly all cars the gear is changed by a hand lever pivoted at the right-hand side of the frame and working in a slotted quadrant. Recesses in the quadrant receive a safety catch worked by a finger lever on the hand lever, and hold the latter in the different positions to which it is set in changing gear. The gate-change quadrant is so called from its having two or more slots side by side, and an opening or gate between them through which the lever is moved with a lateral motion in passing from one slot to the other. In this case the different gear sleeves have separate forks and actuating rods which are selected by the hand lever and its connections as the lever is moved sideways. Strong spring retainers should be fitted for automatically locking the rods, forks and gear sleeves that are not at the moment under the direct control of the hand lever.

A special catch of some sort should be provided to prevent the gear lever being moved so as to bring the reverse into action in mistake for one of the forward gears.

The Live Axle.

To the rear end of the first gearshaft is connected, by a universal joint, the cardan-shaft proper. The power is transmitted to the balance-geared axle by bevel or by worm gearing, and the speed reduction between the motor and road wheels is made at this point, the bevel pinion on the cardan-

shaft being only a fraction of the size of the bevel wheel on the balance gear casing. Sometimes a second universal joint is introduced near the rear end of the cardan-shaft. To be really universal, the two axes of the joint should intersect, but this is seldom the case, and it is not of great importance. The joints are used to compensate for the movement of the springs, which, of course, in this case, come between the road wheels and the frame on which the variable gear box is mounted. The parts of the shaft should be as nearly as possible in line during average running conditions; otherwise, an excessive amount of work will be put on the joint or joints. Some longitudinal play should also be provided for in the shaft.

In this type of transmission the road wheels are driven direct by the parts of the balance-geared axle, which is called a "live axle" to distinguish it from the non-rotating axle on which the road wheels revolve in a chain-geared car. The parts of the live axle are mounted in bearings in a tubular casing, which is in turn secured to the rear springs, and thus to the frame of the car. The casing is enlarged centrally to inclose the balance gear and driving bevel wheel, and also to inclose and provide a bearing for the bevel pinion. In fact, a bearing ought to be, and often is, provided for the tail end of the cardan-shaft both in front of and behind the pinion, as it is very important that the relative positions of the bevel pinion and bevel wheel should be perfectly maintained. Not only is there a tendency for the bevel wheels to push apart, but, owing to the resistance to propulsion offered by the road wheels, the pinion tries to climb up the bevel wheel, and so rotate the axle casing. This should be met by providing the casing with a radial arm, which should extend forward about as far as the forward universal joint in the cardan-shaft, where it should be connected firmly, or with a small amount of elasticity, to the car frame. A neat way of resisting the rotative tendency of the live axle casing is to dispense with the rear universal joint and continue the part of the casing containing the tail of the shaft, along the shaft,

nearly to the front universal joint. This answers the purpose well, and makes for simplicity at the same time.

The Gear-box.

The spur wheels of the change speed gear are inclosed in a gear-box, which serves several purposes: first, to provide a framework in which the spindles may be mounted in bearings of fixed relative position; second, to exclude dirt and wet, and, third, to hold a quantity of gear-case oil for lubricating the wheel teeth. The spindle bearings are usually lubricated with oil through pipes leading from the lubricator on the dashboard. The balance gear is similarly inclosed and lubricated.

Control of the Gear.

The principle on which most modern gears are modeled is described above, but there are many variations. The most popular consists in having two sliding sleeves instead of one. There are several advantages in this. The shafts can be made much smaller, which minimizes the tendency to spring and reduces the noise in the gears. The gear-box, too, can be made neater and lighter.

In the two sliding sleeves type of gear, of course, there is a shifting fork for each pair of sliding gears, as well as for the reverse. In order that these three forks can be operated by one lever, and so that no two sets of gears can be put into engagement at the same time, which would entail serious damage to the mechanism, what is known as the gate control is used.

The hand lever at the side of the car, which is used to operate the change speed gear, works in a quadrant having three parallel slots with a short cross slot joining them. The lever cannot only be moved forward and backward, but also can be slid sideways, carrying with it the short lever which engages with the three rods which operate the three sliding forks of the gear. Each rod has at its end a claw or slot, and as the lever is moved sideways through the slot connecting the three parallel slots in the quadrant, it engages

with one or the other of the three claws. Until the lever is moved into a position where it can be pulled through from one slot to the other it cannot, of course, be disconnected from the claw and rod which it is operating, and when it is moved into such position the rod is so situated that the pair of gears it operates are not in mesh with any other wheel.

Direct Drive on Top Speed.

A variation of the gear wheel sliding type of change speed which has proved very popular is that in which the drive is direct on the top speed. In this the drive is taken from the end of the primary gearshaft to the countershaft or propeller shaft as the case may be, and is absolutely direct from the engine on the top speed. On the other speeds the drive is transmitted from the forward portion of the primary shaft to the secondary shaft, and thence back to the rear portion of the primary shaft. From this point it is transmitted in the usual way. In this arrangement the direct drive on top speed is noiseless and particularly efficient, for the drive is not transmitted through any of the gear wheels, and there is one less change of direction than in the chain-driven type. On the other speeds, however, there is one additional change of direction as compared with the chain-driven type, and an additional pair of gear wheels is in operation, causing increased friction and noise.

Some designers arrange for having the third speed direct instead of the fourth, and this variation has something to recommend it, for, with a third speed a little higher than usual it practically becomes the normal, and the high speed is only used when the drive is comparatively light, and a little extra friction is not of so much consequence. Besides, the large gear wheels of the high speed do not make as much noise as the smaller gear wheels of an indirect third would do.

A variation which has been adopted by some important firms has a good deal to recommend it and seems likely to become more popular. Its object is to combine the advantages of both the leading types; that is to say, while the

drive is direct on the top speed there is only a single change of direction in the others, as in the case of the standard Panhard type. This variation is fitted to Mercedes cars.

Direct Drive on all Speeds.

There are certain cars which have a direct drive on all three speeds, and the arrangement may be described as follows: The change speed gear-box is on the back axle. The propeller shaft has mounted on its extremity three bevel pinions which mesh with three bevel wheels of different sizes on the live back axle. These bevel wheels are free to revolve on the axle unless locked to it by a sliding expanding star key. A change of speed is effected by locking each set of these wheels alternately to the axle, the other two meanwhile running free. Another bevel wheel mounted on the opposite side of the live axle from the three loose bevels similarly gives the reverse when locked to the live axle. The gear is in the out-of-drive or neutral position when none of the bevel wheels are locked to the live axle.

Gears in Mesh and Sliding Feather.

The sliding feather engagement consists of an arrangement, as the name indicates, of sliding feathers which determine which pair of wheels in the gear-box transmit the power, all the others running loose on their shafts and being constantly in mesh.

Constantly Meshing Gears Operated by Clutches.

There are several types of these operated respectively by expanding, positive, and frictional clutch arrangements. They possess two characteristics in particular of great value, namely, (1) very short shafts can be adopted, and (2) the gear wheels being in mesh the teeth cannot be injured by clumsy manipulation, and the arrangement is, consequently, to a considerable extent, fool-proof.

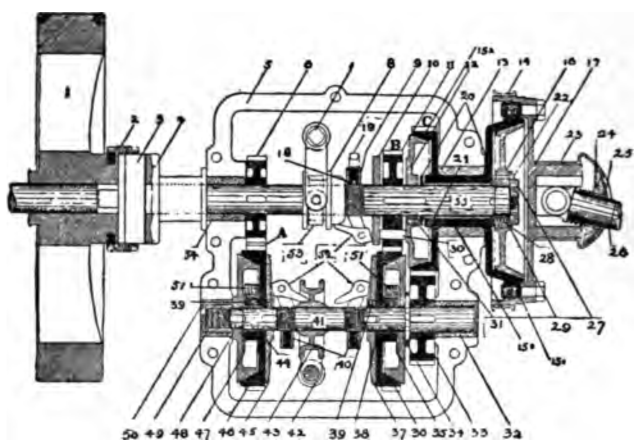
The Expanding Clutch System.

The De Dion gear may be taken as an example of this type. On the secondary shaft are mounted clutch boxes to which

are fixed the gear wheels, both boxes and gear wheels normally revolving idly on the shaft. Inside the clutch boxes are expanding fiber-faced clutches fixed on the shaft and operated by a lever on the steering column and a ratchet inside the hollow shaft. By expanding one or other of these clutches the corresponding box with its gear wheel becomes fixed to the secondary shaft, and so communicates the drive to the bevel pinion and then by the bevel wheel to the rear axle. See Clutch.

The Friction Clutch System.

This is well exemplified by the change speed gear which is illustrated. The diagram gives a sectional view through



Change Speed Gear with Friction Clutch.

the center of the gear-box. It has two forward speeds and a reverse.

No. 55 is the primary shaft driven by the engine, and on this shaft are mounted the driving pinions, 6 and 11, revolving always with it; 41 is the secondary shaft on which are mounted to run freely the gear wheels 46 and 36. On the shaft 41 is also a pinion 33, which is fixed to it, and is always revolving, and meshes always with the gear wheel 15A, which is part of a sleeve 15B surrounding the right-hand end of the

primary shaft 55, and running in the long bearing and free to run independently of the shaft 55. At the outer end of this sleeve 15B, is the clutch 15C, its male portion 16 engaging with it.

The two gear wheels, 46 and 36, are provided with clutches by means of which they can be gripped to the shaft. 46 is in constant mesh with a gear wheel not shown, which is in turn meshed always to the pinion 6. 36 is always in mesh with 11. It will be seen therefore that when the primary shaft is rotating, the gear wheels, 46 and 36, are also rotating, 46 in the same direction as the primary shaft, and 36 in the opposite direction. While thus rotating on the shaft 41 they run on anti-friction sleeves.

The drive from the gear is taken direct from the clutch 15c on the sleeve 15b, which is always revolving with the cardan-shaft and the rear live axle. The shaft 55 revolves constantly with the engine, being coupled by a flexible joint direct to the flywheel boss.

Two hand-levers are used to operate the gear. One for the top speed, which is direct, and the other for the low speed and the reverse, which are by means of the secondary shaft. These hand-levers simply put in and out of operation the three clutches which operate the gears.

We shall first describe the drive on the top speed, which is direct.

It will be seen that inside the gear wheel 15a on the sleeve 15b is a coned clutch male member 12 which revolves with the primary shaft 55, but is free to slide slightly along it. A similar male clutch member 16 is fixed at the end of the shaft 55, and between these two clutch members the sleeve 15b can be rigidly nipped. To bring the two clutch members together there are provided three pivoted dogs shown at 52, pivoted on a collar screwed and clamped to the shaft 55. The small ends of the dogs press against a disk 10, which in turn presses three pins, one of which is shown at 30. These pass through holes in the pinion wheel 11, and in turn press against the male clutch member 12. The long ends of the

dogs come into contact with a sliding cone 8 on a collar which can slide along the shaft and is operated by the fork 7 connected with the hand lever.

When the collar 53 is slid along to the right it lifts the long ends of the dogs, the shorter ends pressing with considerable force against the disk 10, and drawing together the two male clutch members 12 and 16, gripping the sleeve 15b firmly between them and causing it to revolve with the shaft 55. This is the top speed, with a direct drive right through from the engine crank shaft to differential gear on the rear axle. During the time that the direct top speed is in operation it will be understood that the shaft 41 is revolving, and the gear wheels 46 and 36 are also revolving upon it, both at different speeds, and one in the opposite direction (46).

We shall now describe the operation of the low gear. During this operation the clutch 12-16 is, of course, free, and the sleeve 15b is free of the primary shaft. The low speed is driven by the pinion 11, which is, as we have seen, keyed to the shaft 55, and meshes with the gear wheel 36, normally running free on the shaft 41. This gear wheel 36 is provided with a clutch consisting of the male cone 34 keyed to shaft 41 on one side of it, and a flat disk 37 free to slide, but not turn, upon the shaft 41. Similar dogs to that described for the top gear clutch, and one of which is shown at 52, are used to force the disk 37 up against the back of the gear wheel 36, and in turn to force this into engagement with the male clutch member 34. When this clutch, therefore, is in operation the pinion 11 drives the gear wheel 36. This being now engaged with the shaft 41 the latter revolves with it, and the pinion 33 keyed upon it drives the sleeve 15b through the medium of the gear wheel 15a, which is part and parcel of the sleeve 15b, from which the drive is direct to the back axle. The dogs are operated by the sliding cone 43, which in this case is double-ended, the right-hand end operating the clutch we have just described, and the left-hand end operating the reverse, with which we shall now deal.

The reverse gear is driven by the pinion 6 keyed to the

shaft 55. This pinion drives a second pinion, which is not shown in our diagram, but which is, in turn, in mesh with the gear wheel 46, which it consequently keeps constantly turning in the same direction as the shaft 55, but at a lower speed. This gear wheel 46 is also provided with a clutch operated similarly to the low-speed clutch by one of the dogs shown at 52. When the ends of these dogs are forced up by the movement of the cone along the shaft they press the flat disk 45 up against the flat face of the gear wheel 46, and force it into engagement with the male cone member 48 rigidly mounted on the shaft. The shaft 41 must then turn with the wheel 46 and in the same direction and at the same speed, so that the pinion 6 drives 46 (through the intermediate pinion) in the same direction as itself; 46, being now rigid with the shaft, transmits motion in the opposite direction through the medium of the pinion 33 to the gear wheel on the sleeve 15b, and so drives the car in the reverse direction.

The arrangement of the clutches is such that there is no end thrust on the shafts on which they operate. The collars which carry the pivoted dogs 52 are screwed on to the shafts, and can be adjusted nearer or further away from the clutches by simply screwing them round. When adjusted, they are clamped to the shaft by the pinching screws 40 and 19. The clutches are kept normally out of engagement by small helical springs between the male and female portions of the clutches. Four of these springs are shown in our illustration. In this particular arrangement there is no main clutch. As will be seen, the engine can be declutched from the car by operating any of the change speed gear levers.

Epicycloidal Gears.

The epicyclic or "crypto" type of gear has come very largely into use for automobile transmission purposes. The arrangements vary largely, and form the subject matter of many patents, but, generally speaking, the gears approximate very closely to one another, and the changes of speed are obtained by rendering different elements stationary or active.

In one typical form of epicyclic gearing a center or sun wheel is surrounded by an internally-toothed wheel of considerably larger diameter. One or more planet pinions are mounted on a carrier and gear with both the other wheels. All the wheels are in one plane and form a concentric system. By locking the sun wheel, the internally-toothed wheel, or the pinion-carrier to either the driving or the driven parts, and by holding one or other of them stationary, forward and reverse motions can be obtained at different ratios. The wheels are always in mesh, and the changes of speed are brought about by the application of brake bands, and, therefore, without shock. See Epicyclic Gear, under "Gear, Change Speed."

A number of transmission gears have been devised in which the motor-shaft and other shafts are all arranged transversely of the car and so parallel to one another. The various speeds are generally obtained by means of sliding spur wheels, and the motion is conveyed from shaft to shaft by chains.

The parallel system of transmission should, theoretically, be considerably more efficient than systems in which the power is carried round one or more right angles, but the theory is not well borne out in such severely practical tests as hill-climbing competitions. The restrictions of space make it difficult to set a large motor transversely of the car.

Belt Drive Gearing.

Other systems of change speed gearing have been in use from time to time, but are now obsolete. Of these the belt drive was at one time most popular, especially in Europe, in connection with cars of the Benz make. It had considerable advantages in the way of silence, smoothness of working and simplicity; but the constant stretching, slipping and breaking of the belts, due largely to the use of unsuitable material and exposure to wet and mud, and some lack of efficiency, gradually led to its abandonment, though it may possibly come in again for small cars.

Usually the arrangement for belt-drive comprised two pul-

leys of unequal diameters, securely keyed to the motor shaft and driving a countershaft, from which the power was transmitted by side chains to the wheels. The drums on the motor shaft were made double the width of those on the countershaft, so as to permit of lateral movement of the driving belt. The countershaft pulleys were in pairs, one fast and the second loose, and set alternately with the remaining pulleys driven by the other belt, so that when the countershaft was being driven from the motor shaft by, say, the high-speed drum, the low-speed belt was on its loose pulley and out of action.

The belts were shifted by forks operated from the driver's seat, and arrangements were made that the striking gear should first let both belts run loose, and then set the low gear in operation, a further movement freeing the low speed, and allowing the high gear to come into action.

When belt-driven cars were in vogue attempts were made to vary the gear by regulating the amount of slip of the belt. Experiments have since been made with a system of driving by means of a large circular disk, against which is pressed a leather-faced wheel, connected with the countershaft.

The Auto-Mixte Gear.

An idea which does not come under any of the heads already dealt with is to be found in the Auto-Mixte, a Belgian car. Instead of a change-speed gear, a dynamo and accumulators, or storage battery cells, are used, and the clutch and brake are magnetic.

Under ordinary conditions, the engine drives direct through the armature of an electric dynamo to a magnetic clutch of the disk type, and thence direct to the rear live axle. The dynamo is shunt wound, and when the load of the engine is light, part of its power is utilized to generate current in the field of the dynamo, which current is stored in an accumulator consisting of 28 cells connected in series. When the load on the engine is heavy the dynamo may be used as a motor to assist it, the current being supplied from the ac-

cumulators. By means of a controller the speed can be varied by sometimes letting the engine drive the rear axle only—letting it partly drive the rear axle and partly charge the accumulator, or by letting it drive the rear axle, assisted by the motor. The controller is operated by a hand lever at the side of the driver and suitable ampere and volt meters are arranged to show exactly the condition electrically of the accumulator and the dynamo.

A specialty in this system is the magnetic clutch. The end of the motor shaft carries a large electro-magnet facing a flat disk mounted on the propeller shaft. A similar electro-magnet is held stationary in the car frame, and faces the back of the disk. When current is passed through the coils of the motor shaft magnets, they magnetically clutch the disk and transmit the drive. When current is passed through the coils of the stationary magnets they similarly attract the disk and act as a powerful brake. A hand controller, determining the voltage of the current passing through the magnet, allows of the engagement or disengagement of the clutch being accomplished gradually.

The Art of Gear Changing.

To effect the change appropriate to the grade swiftly and without noise, without loss of way and without shock to the car, or accidental disturbance of the steering, and without racing the engine, is generally supposed to constitute the whole art of gear changing. It is an important part, but only a part, for there still remains the question of making the change at exactly the right time.

When the car on its top gear comes to a uniformly graded hill, steep enough to cause the speed to fall off in spite of the throttle having been fully opened and the spark adjusted to its best position (see Ignition, Timing), the driver can at his will and discretion allow the engine to continue to pull for a considerable time on that gear, but with the engine getting gradually slower and consequently developing less and less horse-power. To a certain extent this is what he should do

to get the best result from his car, provided that he changes down to a lower gear at that moment precisely when he can just maintain his speed with the speed lever in the new position. As a test of changing at the right time, it is to be noted that if the hill continues to be of uniform slope, a good driver when seeking for the best possible speed of traveling should not find that the car gains speed on the lower gear, for that would prove that he changed too late—unless perchance he was driving with the specific object of economizing in gasolene.

A bad driver is as likely to change too early as too late, that is to say he will change gear at a moment when the engine cannot rotate fast enough with the lower gear ratio to attain to the speed which he already had. He then not only loses speed and wastes time, but he wastes gasolene and does no good to his engine by racing it.

A little practice shows the driver that an appreciable amount of way is lost during the brief interval between the unclutching and reclutching necessary for the change of gear, so that when he is near the summit of a hill he often deems it policy from the point of view of time and fuel saved, to avoid interrupting even for so brief a time the action of the engine. He remembers that as soon as the crest of the hill has been surmounted, there will be a second waste of time in changing up again to the top notch.

What Happens in the Gear-Box.

The ordinary gear requires that the teeth of the wheels which are in mesh shall be disengaged, and others substituted in their place by a sliding movement.

Suppose the car in motion with any one set of gear wheels, when it becomes expedient to change gear. The person driving, first, and before pulling the speed lever, presses down a pedal so as to disengage his clutch. The effect of this is that the engine no longer transmits any power to the road wheels through the gear, though the gear still rotates by its own inertia. Then with the speed lever he disengages one pair of

wheels and quickly attempts to thread the teeth of the pinion he wants to use into the spaces of another pinion which stands ready on the shaft which drives the road wheels.

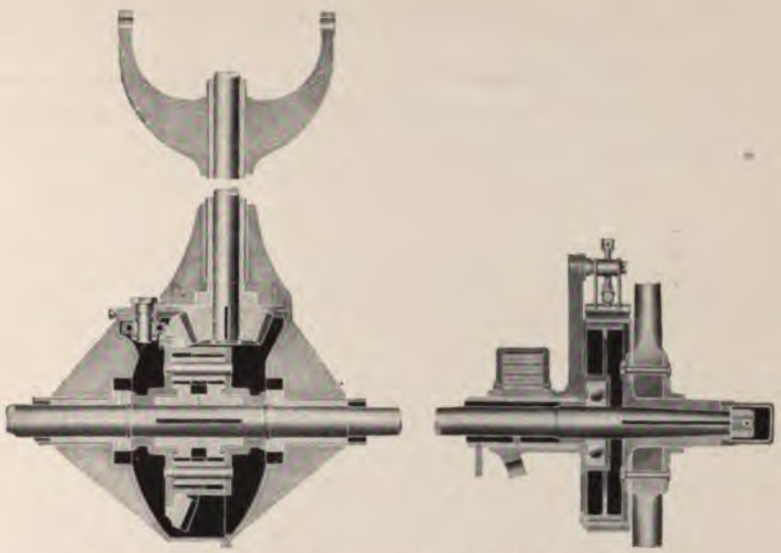
If the spaces are just opposite the teeth and rotating at the same pace they will slip into place sweetly; if not, there is grinding and perhaps a few bruised teeth. Practice alone can teach the exact amount of hurry to use in pushing the new pinion into place, but in no case should any strong muscular effort be expended on the lever. In gear changing the driver must work accurately, gently and at the right moment.

Selective Sliding Gear.

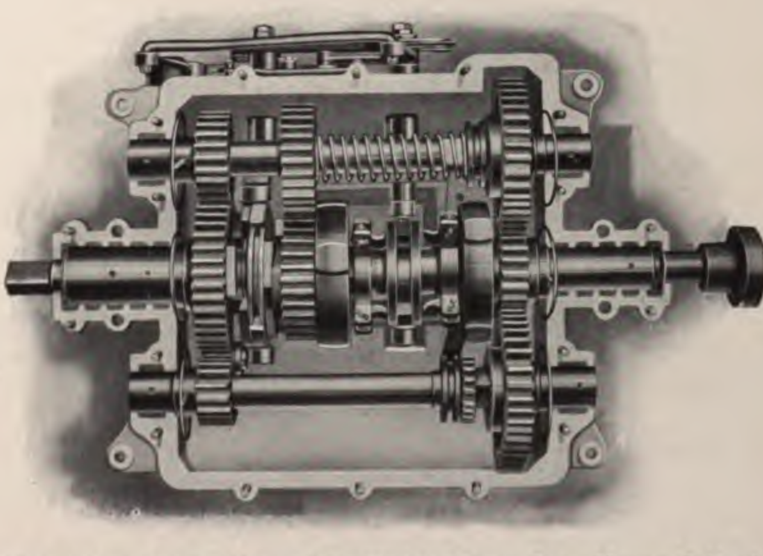
In the most modern American parlance the type of change speed gear or transmission in which any change can be made without passing through the intermediate gears is known as selective system. Thus, in the 1909 Winton six-cylinder car, for example, the gear change mechanism is of this type, supported on annular ball bearings, with three forward speeds and reverse. There is direct drive on the third speed through internal and external gear combination. The selective mechanism makes it possible to enter neutral position, but impossible to engage any new set of gears while the clutch is engaged.

Gear-Changing Troubles.

One often hears of great difficulty in gear changing on some particular car. An experienced man will often come across a car in which he finds it practically impossible to get his first speed or reverse into mesh without grating, though his other gears seem to go in quite noiselessly. The reason for this is generally to be found in the clutch, and points to the driven member of the clutch continuing to rotate after the clutch has been withdrawn. Thus, when starting from a standstill, as soon as the clutch pedal has been depressed, the driver attempts to engage his first speed or reverse whilst the first motion shaft is still spinning. This means engaging a rotating spur wheel with a stationary one, and consequent noise.



Rear Axle and Differential—The Welch Motor Car.



Three Speed Transmission—The Welch Motor Car. Upper Half of Case Removed.

When the second and third speeds are engaged, both shafts are rotating, and consequently engagement is easier, and there is little or no noise. If this grating of gears occurs and is not attended to, it will result in the first speed being worn out rapidly.

There are two or three causes for the clutch's continued rotation, one of these being lack of lubrication in the old type of clutch. By the old type is meant an ordinary leather to metal cone clutch, with the spring outside the clutch. In most clutches of this type the crankshaft or driving-shaft extends a short way into the driven shaft, the latter forming a thimble bearing on a driving-shaft. When the clutch is held out the crankshaft rotates inside this thimble bearing, and, of course, requires lubrication. This bearing is difficult to lubricate, owing to the centrifugal action tending to eject any oil, and frequently no means are provided for its lubrication. A grease cup should be fitted, but the cap of this should be fitted with some safety device; otherwise it will be rapidly thrown off.

In the more modern type of self-contained clutch the trouble may be due to the clutch fork. Generally the clutch is withdrawn by a fork engaging a grooved boss on the sliding member. This fork should bear against the boss equally on both sides. If this is not the case it will put a tilt on the sliding clutch member, causing it to bind on the driving-shaft on which it is mounted. This causes friction between the boss and the shaft, and consequent rotation. Further, in this type of clutch a stop should be fitted to prevent, on the pedal being depressed, the sliding member being pushed out too far so as to come into contact with the radial portion of the clutch or flywheel. In many cases a clutch brake is fitted to stop the clutch directly the pedal is used, and this generally takes the form of a pad held close up against the clutch, and against which the clutch member bears when out. Obviously, the lighter the sliding clutch member is, the quicker it will slow up and the easier changing gear will be.

Adjusting Clutch Gears.

Although the principle and action of the expanding clutch gear are known thoroughly by many owners, it is frequently a mystery as regards adjustment, except for the simple tightening up of the clutches when slipping. The other contingency calling for adjustment, namely, when the gear handle does not move equally on each side of its free position to engage the speeds given at its extreme positions, is a somewhat more complicated business, and necessitates a certain amount of knowledge of the gear deeper than that involved by a comprehension of its principle. The cause of the handle moving further to one side than the other is evidently that one clutch has a greater distance through which to expand than the opposite clutch before it comes into contact with its box and grips.

If this inequality of motion is to be righted, the one clutch must be expanded and the other contracted until both have to expand through the same distance to grip their respective boxes. To do this, the universal joint at the end of the rack outside the gear-box, to which the gear-changing lever from the change-speed lever on the steering column is attached, must be dismantled and the spring catch lifted.

The catches vary in arrangement on models of different dates, but in all cases the action is the same, namely, that of a small bolt dropping into a keyway cut along the rackshaft. Having lifted the bolt, turn the rack from right to left, that is, counter-clockwise, six complete turns, and then, making sure that the keyway is beneath the bolt hole from which the catch has been drawn, pull the rack out as far as it will come. Note should previously have been made as to which way the handle moves too far, and, before dismantling the striking arrangements, the amplitude of the motion of the cap on either side of the line which will be found around the projecting spindle of the gear should have been carefully inspected. Having the rack pulled right out, it should be turned one way or the other, according to the direction in which the cap moves too far for a half revolution—if the difference

is small; a full turn if fairly large, or any amount that may be necessary, proceeding in half turns.

The rack should then be pushed in again, great care being taken to see that a keyway lies beneath the bolt hole, and, when home, it should be screwed up six turns, and the bolt dropped in, and the rack then tried to see if the motion is equal on each side of the free engine line. If it is equal, but too great, the clutches can be tightened further in the usual way, and the striking gear then connected up again.

Theory of Clutch Adjustment.

The theory of the above adjustment is briefly this: The rack consists of a right-hand screw or worm and a left-hand one of a fairly coarse pitch, and the two threads meet in a common point, which normally lies between the two clutches. The keyway is cut so that it is in a line with this juncture of the threads, so that, considered as a rack only, it is immaterial whether the thread is right or left-handed in this line. When the rack is turned through the six revolutions, its function as a worm comes into play, and the clutches are both contracted; by stopping with the keyway true with the bolt hole, the rack is in its true pitch position, and may be withdrawn, the withdrawing action bringing both sets of clutch-expanding mechanism on to a single thread, that is, instead of one set of clutch pinions being on the right-handed portion of the rack and the other set on the left-handed part, both are on the right-handed thread. When the rack is pulled out as far as it will come, and the adjusting turns given to it, the right-hand thread of the rack acts as a worm, and, gearing with the clutch pinions revolves them, contracting one clutch and expanding the other. The rack is then pushed in, the clutches expanded by the six clockwise turns of the rack, and if slack, are adjusted in the ordinary way by turning the rack to expand the clutches equally.

Change-Speed Gear Connections.

After a car has been in use for some considerable period, or rather a more correct way of putting it would be to say has

run some thousands of miles, there will be more or less play in the joints of the connecting rods to the change-speed gear, brakes, carbureter, etc. The looseness occasioned by such wear is productive of a very annoying rattle, and frequently, in the case of the change-speed gear lever connections especially, causes a slight maladjustment of the parts, so that the change-speed lever has to be pushed beyond its notch, and then brought back to it again, in order to insure the wheels meshing over the full width of the teeth. The remedy is to have the holes reamed out a little larger, and to have correspondingly larger pins or bolts fitted, when normal conditions will be renewed. In many instances the actuating rods to the carbureter, commutator, etc., are coupled up to the levers by bending over the ends of the rods at a right angle, and securing them in position by a washer and split pin. This is not very good practice as a general rule, but it has to be resorted to under certain conditions. As the levers to which such rods are connected are usually of brass, there is little possibility of enlarging them successfully, so that the remedy for rattle and looseness here is to fit a spring washer in place of the plain one.

Why Gears Come Out of Mesh.

Take as an example a somewhat curious case of gears coming out of mesh when the clutch had been withdrawn. This happened on the first and third gears, but never on the second. An investigation disclosed the sliding sleeve working on the primary gearshaft, and carrying the first and third speed gear wheels at either end, with the second speed gear at the center. The sliding sleeve was found to be a very loose fit on the square shaft, it being a somewhat ancient car, and there was considerable end thrust on the shaft on withdrawing the clutch. Now, what caused the trouble was undoubtedly this: When either of the end gear wheels were in mesh, the natural tendency to spring apart caused the sleeve to bind on the shaft owing to its loose fit. On the withdrawal of the clutch, the end thrust caused a longitudinal

movement of the shaft, which carried the gear wheels sufficiently out of mesh to pull the change-speed lever out of its notch, when it easily slipped sufficiently to bring the gears right out of mesh. With a quadrant provided with square notches for the locking catch, such a thing could not, of course, have happened, but this particular quadrant had ratchet-shaped notches.

"Knocking" in Gears.

A fruitful source of knocking, and one sometimes very difficult to locate, arises from a slackness between the squared end of the propeller-shaft and the socket in which it works. This is particularly noticeable when the car is slowing down in ascending a hill, and on occasions when changing gear. To remedy such a trouble, the socket should be enlarged, if there is sufficient metal to do this, and thin steel plates should be inserted to make up a working fit to the squared end.

Quieting a Noisy Motor.

A two-cylinder engine was once handed to a firm of repairers for general overhaul in an attempt at reducing the racket it had hitherto made, to its owner's great discomfort. After taking down and reassembling, a considerable amount of the din was discovered to be due to the steel distribution gear, and this din no resetting or readjustment would abate. It was due to the resonant ring of the metal, and short of substituting fiber and brass wheels, its abatement appeared beyond the bounds of possibility. However, the resource and ingenuity of the repairer were equal to all requirements, for having once more dismounted the wheels he had large diameter countersunk holes drilled in the webs, into which lead was run, and then shaped up. Result, the metallic ring of this train of gears entirely disappeared, and peace reigned where no peace was before. The same effect can be secured by plugging the holes with hard wood instead of lead.

Central Chain Mud-Guard.

Although a centrally placed chain picks up less dirt than double side chains when dirty weather prevails, it is as well to take some step to protect it. A simple arrangement is to fix to the bottom of the car a light iron frame, covering it with leather laced or strapped to the frame to permit of ready removal. With such an arrangement, allowance must be made for the movement of the carriage body upon the springs, otherwise the gear case rapidly becomes a wreck.

Protecting Universal Joints.

Particular attention should be given during wet and muddy weather to the universal joints which are employed on cars with transmission by propeller-shafts. If such joints are unprotected, there is every possibility of liquid mud being splashed over the joints and finding its way therein. So long as the car is moving, there is little fear of accident occurring through jamming, though, of course, such liquid mud can do a great deal of harm while being churned about in these joints, inasmuch as it very frequently must contain hard, gritty substances which act as an abrasive on the working surfaces of the joints. The real trouble lies in allowing the mud to dry in the joints during a period of inactivity of the car.

A very simple and effective method of protecting the joints, and one which is carried out by many manufacturers, is to incase the whole of the joints in a soft pliable leather covering, this being stitched over the joints in such a manner as to allow ample room for the greatest possible freedom of movement without tearing the leather. If one contemplates inclosing joints of this kind in such a casing, the parts—provided the car has had some wear—should first be taken down and thoroughly cleaned with kerosene, then wiped dry, and filled as full as possible with good motor grease before the leather covering is placed over the joint. In some cases and for some reasons it may not be possible so to inclose these joints, and where such is the case it is an excellent plan oc-

casionally—in fact, very frequently—during wet weather to inject kerosene into them by means of a syringe, and after allowing the superfluous oil to drain away, to inject by similar means a quantity of good heavy-bodied lubricating oil.

If a further refinement is thought necessary, it is not a difficult matter to fit an old pneumatic tire valve, with the valve parts withdrawn, into the leather tube, so that grease can be fed to the interior through the valve by means of a grease injector having a suitable nozzle. This arrangement makes for the perfect working of the part, the suppression of all rattle if the joint is at all loose, and the salvage of any key or nut that might become detached and would otherwise drop upon the road and be lost.

A Typical Modern Gear.

In a typical modern change speed gear (Locomobile) the four-speed selective system is employed, and it is described as follows:

"The selective transmission is more desirable than the progressive transmission because it is possible to pass from one speed to another without passing through any gears; also, the gear box is shorter; and, as the sliding members move only in one direction they need only be beveled on one side, and as the portion of the gear which is beveled is not useful in driving the car it is obvious that in the selective system gears can be used with narrower faces. The selective transmission is easier to operate, as the change gear lever has a definite stop position for each change of gear. There is no 'feeling for the gear' as in the progressive system. It is also possible to go from fourth speed back into first speed without passing through any gears.

"The advantages of four speeds over three are numerous, and include the following:

"The car may be driven with the high gear engaged at a high rate of speed on level roads without racing the motor; the third speed is powerful enough to propel the car up all hills, unless extraordinarily steep, and at the same time not

race the motor, as would be the case with the three-speed transmission, the intermediate gear being used.

"Also, and very important, a four-speed car may be started from a state of rest and accelerated very much more rapidly and with much less shock to the motor and gear box than a three-speed car. For example, the regular practice with the three-speed transmission would be as follows:

First speed....................10 miles an hour
Second speed.................20 miles an hour
Third speed ....40 miles an hour

It will be noticed that the increase of twenty miles an hour between the second and third speeds is the greatest, and furthermore, it is always the difficult gear change to make because in this case the car naturally requires more power than in the first cases.

"With the four-speed transmission the practice would be as follows:

First speed...................10 miles an hour
Second speed.................20 miles an hour
Third speed..................30 miles an hour
Fourth speed.................40 miles an hour

or an even increase of ten miles an hour. A car with the four-speed transmission can be picked up much more rapidly, is more flexible and more easily handled, is more efficient and more desirable than a car equipped with the three-speed transmission."

Change-Speed Lever—The lever or the handle by which variable speed mechanism is operated. It "throws into gear" the wheels, etc., by which the required speed is obtained.

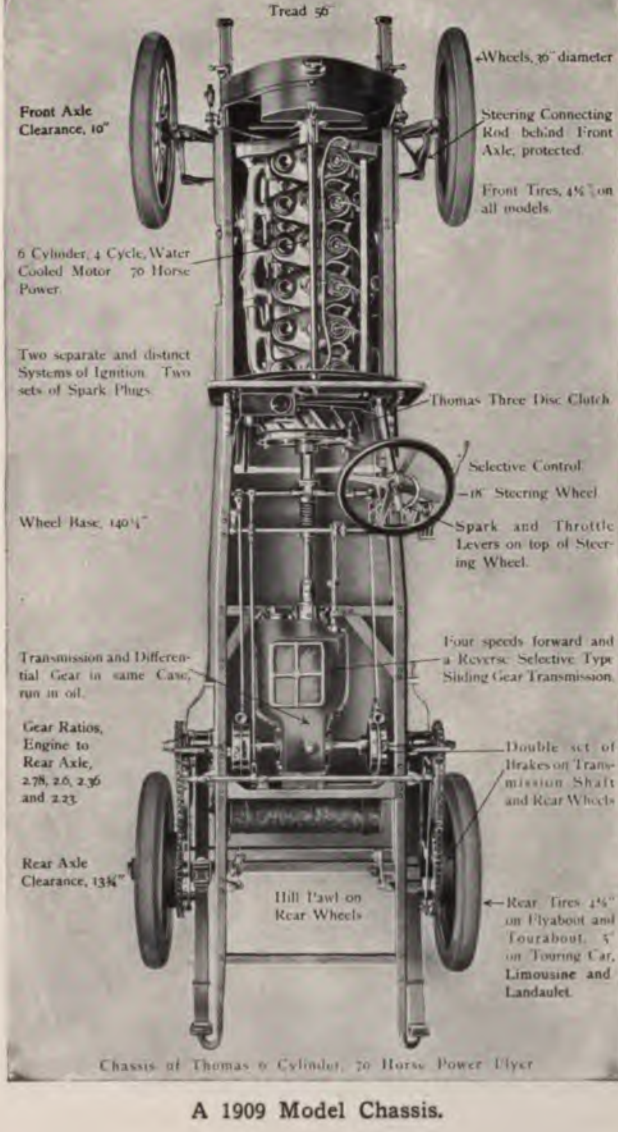
Changing Gear—See under Driving.

Changing Ignition System—See Electric Conversions.

Channel—A furrow or groove, as that in a pulley-wheel which receives the belt.

The term is also applied to the trough used to conduct molten metal, as iron or steel, from the furnace to the molds.

Channel Iron—Iron rolled in the shape of a channel, or



Chassis of Thomas 6 Cylinder, 70 Horse Power Flyer

A 1909 Model Chassis.

like three sides of a hollow square, combining great strength with lightness. Other shapes are T iron, H iron, L angle iron, in all of which a horizontal and vertical plane are combined.

Chaplet—In foundry work, a device for holding the core of a mold in position; a metallic chuck for holding castings in place in a turning-lathe; also applied to a form of tire-bolt.

Charcoal—A substance made by subjecting wood to a process of smothered combustion. Used as fuel and for many purposes in the arts.

Charge—The quantity of explosive mixture drawn into the combustion chamber or cylinder of a motor engine at one stroke of the piston; the quantity of electricity distributed over the surface of a body, as a prime conductor.

Charge, Electric—See Charge above.

Charging Batteries—See Battery.

Charging from Ordinary Switch—See under Care and Maintenance.

Charging from a Primary Battery—See under Care and Maintenance; also Recharging Batteries.

Charging Storage Cells from an Alternating Circuit—See under Battery.

Charging Tanks—See under Driving.

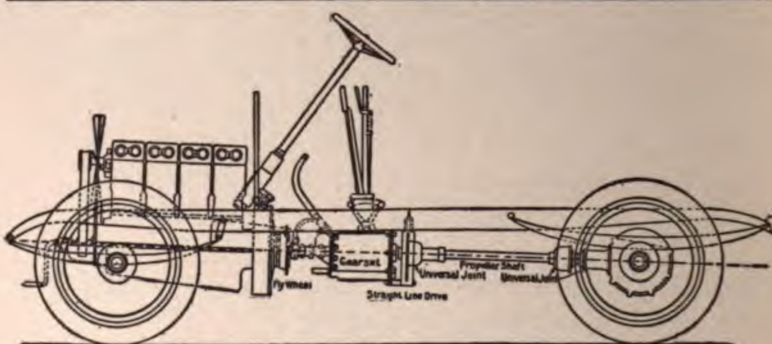
Chase—To form a screw thread on a revolving piece of material by means of a tool known as a chaser.

Chassis—A term adopted from the French. It strictly means frame, but as generally used in the automobile world it includes not only the framework of a car but also the wheels, springs, motor, gear, etc., mounted on or suspended from the frame; in fact, everything but the body. The carriage work or body is mounted on the chassis to make the complete car. See Motor Car. (Pronounced "shah-see".)

A Typical Modern Chassis.

The following description of a typical modern American chassis for a 40 horse-power car will be found of interest:

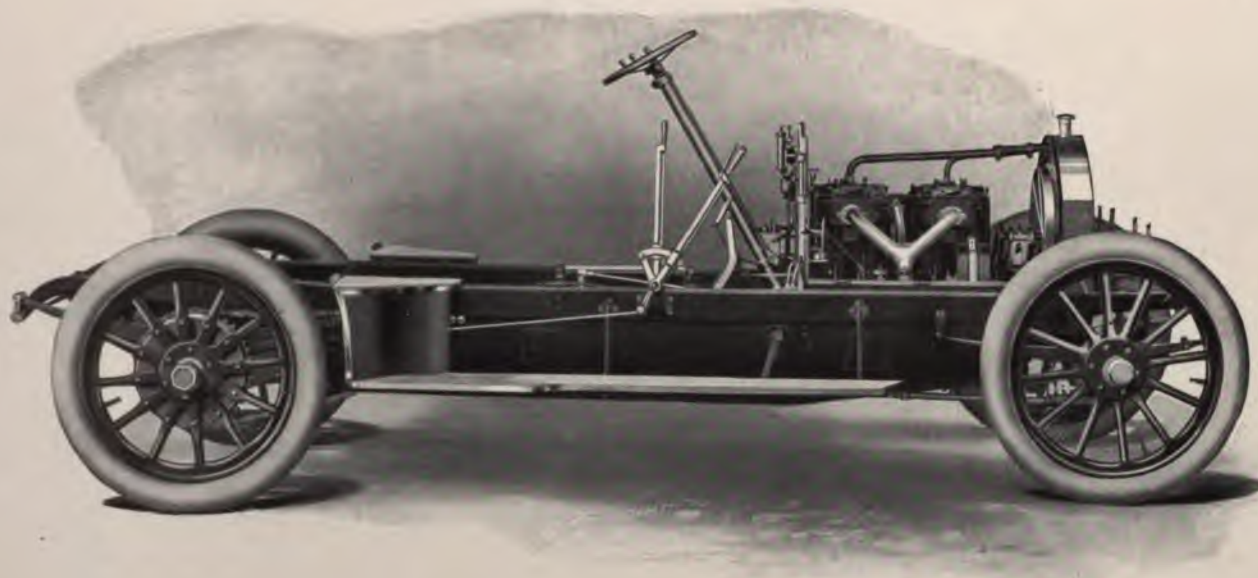
"The frame is pressed alloy steel, heat treated, and consists of two parallel side members which are narrowed near the dashboard so as to increase the steering angle and make it possible to turn the car in a short radius; at this point the horizontal flanges of the side members are increased in area to secure additional stiffness. The side members are braced near the front of the frame by a pressed steel cradle supporting the radiator, the latter being carried slightly back of the front axle. This adds to the attractiveness of the car, and as the motor is placed further back on the frame than ordinarily, a



Knox Chassis, Showing Straight Line Drive.

much better distribution of weight is secured. The pressed steel frame is also braced and stiffened by the motor-base casting, the projecting arms of which extend to the side members and are bolted to them. The motor base is of manganese bronze, as strong as steel, so the great strength of the structure at this point can be appreciated. A pressed-steel cross member near the center of the frame carries the operating mechanism; two pressed-steel cross members support the transmission case; and a cross member at the rear not only braces the side members but acts as a support for the body, the corners being braced with triangular gusset plates. A steel tube connects the extreme rear of the side members and obviates any twisting action at this point.

"The rivet holes are drilled instead of being punched, and



Side View of Locomobile Type "I" Chassis.

the rivets are put in hot, and each one tested; each frame is carefully assembled throughout, is inspected thoroughly, and all the holes needed for the purpose of assembling are jig-drilled.

"Four semi-elliptic springs are employed, unusually wide and long; and as they are all made from alloy steel, both remarkably easy-riding qualities and great strength are secured. The springs are assembled with flake graphite between the leaves; this gives a free motion and excludes moisture and prevents rust. A rather important and exclusive feature is the fact that the spring eyes are provided with bushings which are wider than the spring eyes, so that when the bolts are put through and tightened up there is no wear on them and the springs always work freely. Provision is made for lubrication. Rear springs are carried outside the frame; the front ends are secured to the countershaft brackets, the rear ends fastened to the spring-hanger tube, provision being made for lubrication where necessary. The springs are secured to the spring seats by strong drop-forged clips, the nuts being set up very tightly and headed over to prevent loosening.

"The front and rear axles are I-beam in section, most desirable because the greatest strength may be secured with the smallest weight; both axles are forged from a grade of special steel, so tough that it can be bent double when cold. The spring seats are integral with the axles.

"The wheels are of the artillery type, strongly constructed of the best second-growth hickory, thoroughly seasoned. Hess-Bright ball-bearings are used, two bearings to each wheel, every precaution being taken to exclude moisture and grit.

"The exposed mechanism of the car is protected by an aluminum mud-pan extending from the radiator to the rear of the running brake; it is bolted to the frame, the bolt holes being elliptical, making it more convenient to remove and replace the pan. Doors in the mud-pan give access to the carbureter and to the fuel-supply valve.

"The fenders are of aluminum and are very strongly secured

to the chassis by drop-forged Norway fender iron. The front fenders are wide and thoroughly efficient and are provided with wings extending to the frame to prevent any mud from being thrown back when the car is turning a corner. The rear fenders are also wide and are curved down over the rear wheels, effectually preventing any spattering of mud on the body and top.

"The running boards are supported by drop-forged brackets and are widened at the rear. This, in conjunction with neatly designed sprocket boxes, enables one to enter or leave the car in a most convenient manner, plenty of foot-room being provided."

Chauffeur—A professional or paid driver of a motor car. A French word literally meaning stoker or fireman. It dates from the time when the steam car was the only practical type and was probably at first employed in derision. The word has since been applied in France to all autoists, but in the United States and England it is used mainly if not solely to designate a paid driver or mechanic who operates or cares for a motor car. Hence in modern usage one who drives an automobile is not necessarily a chauffeur, but a chauffeur is almost invariably a regular paid driver. A driver's mechanical assistant is usually called the mechanic or mechanician.

The French pronunciation has been adopted with the word and it is usually pronounced like the English words "show fur." It may ultimately be Anglicized, like the related word "chauffer," a small furnace used in chemistry, which has long been pronounced "shaw-fur."

Check—To split, crack or seam in drying, as painted or varnished surfaces, etc.

Check-nut—A nut used as a stop for adjusting the length of a screw or to prevent the turning of another nut.

Check-valve—A valve in a supply pipe which prevents any backward flow of the liquid or gas passing through. Also called Ball-valve, Clack-valve and Non-return valve. See Valves.

Cheek—Either of two pieces which form the sides or corresponding parts of any apparatus or device; for example, one of the jaws of a vise.

Cheese Head Bolt—See Bolts and Nuts.

Chilling—The act of reducing the temperature of molten metal suddenly so as to harden it. The process in casting which produces chilled iron or chilled steel.

Chisel—A steel tool with a blade, flat or curved, having a beveled cutting edge. Used in wood and metal working, either by hand or in a lathe.

Chock—A block used to prevent the movement of other parts of a machine; a device to prevent the movement of the traveling wheels of a portable machine while the gear is in motion.

Choice of a Car—The purchase of an automobile usually involves many important considerations, including those of price, cost of upkeep and adaptability for the buyer's purpose.

The question of choice among the numerous makes and models of cars now offered to the public may be considered under two general heads, namely, in relation to new cars purchased from the makers or an agent and second-hand cars bought from a private owner or a dealer.

"In choosing a car," writes an autoist who has been through the mill, "one has a good many things to consider. First, perhaps, comes the sadly sordid question of cost, and this question has several subsidiary ones tacked on to it. Are you prepared to spend enough to buy a thoroughly sound car of well-known make, and are you prepared to devote a proper amount to its upkeep? Do you realize that a certain annual expenditure above and beyond gasolene, etc., is necessary to a motor car? Or are you only disposed to lay out the price of a good second-hand car? Do the claims of gasolene, of steam, or of electricity appeal most strongly to you? How many passengers do you desire to accommodate, and what horse-power will you consider necessary? Will you

be content with low power which will propel you at decent speed on the level, but will require the lower speeds for hill work, or would you prefer sufficient engine power to carry you up gradients of 1 in 10 without changing down? Do you propose to do your own driving, or is your automobiling to be of so strictly amateur a character that you will keep a chauffeur who will do all the driving? You say your friend has a So-and-so that never gives him any trouble, and you mean to have the same? Well, there is something in that, provided your friend's requirements and accomplishments are the same as your own; but not necessarily otherwise. Perhaps he will sell you his car. There is nothing like knowing the antecedents of a second-hand investment."

There is a widespread opinion that every beginner should learn on a small car of moderate horse-power. He will learn quicker than on a big car, and in the trying days of his novitiate will be less likely to prove a danger to himself and the general public. There is an absence of responsibility about a modest light car, and the driver gains confidence rapidly, whereas the big car proves a constant strain to his nerves. His mistakes, too, prove far less expensive. With a big expensive car ignorance or carelessness may cost him considerable money within the first few months. With a small car he is less likely to make mistakes that cause damage, while the cost of making good such damage as may occur is trifling as compared with the big car. From the pleasure point of view he will derive just as much value from a light car as if he aspired higher before gaining experience, and will at the same time have in reserve the keen pleasure of graduating on to smoother running vehicles of greater horse-power, until the limit which he can afford has been reached. Even when he has attained the summit of his ambition he will still possess a kindly affection for the small light car, and will find it advantageous from an economical, pleasurable, and convenience point of view to keep one in his garage.

Having learnt on the small car, and become comparatively efficient, the beginner naturally aspires higher. If he is a

man of moderate means, in the true sense of the term, he may be satisfied with his small car, though it be but a two-seater. The light car of good construction is cheaper to run than a horse and buggy, even after allowing for depreciation, upkeep, tires, fuel, and interest on capital, and will carry him reliably at an average speed considerably over the legal limit. The addition of a tonneau, however, to the lighter cars makes a very appreciable difference. The initial cost is higher, the wear and tear greater, tires do not last so long, and the consumption of gasolene and oil is increased.

With the three, four, and six-cylinder cars the increase is continued almost in the same proportion, and there is practically no limit upward.

As regards the choice of make only general advice can be given. Do not invest in an absolutely new type made by a firm whose members have not had experience in the motor business.

Do not trust your own judgment. Even a trained engineer cannot tell by mere inspection if a car is all right.

Do not attach too much importance to the advice of interested parties.

If you are absolutely inexperienced and have no friends to whose judgment you can trust implicity, buy on reputation. A car which has been before the public for years, and is in large demand and highly spoken of, must possess merit.

If you have gained a certain amount of knowledge by intercourse with other automobilists, or by reading, inspect the types you think most promising, get demonstrations and trial runs, and then, giving special weight to the public reputation of the firm, and the experience of those friends of yours who have owned such cars, make your decision.

Above all things avoid, if possible, the "cheap and nasty" car. It will probably cost you as much in repairs during a single season as (added to your initial expenditure) horse-power for horse-power, would have bought you the best car on the market.

As regards second-hand cars, never buy without getting ex-

pert and disinterested examination. It is worth paying a few dollars for this. Also try and find out something of the previous history of the car, and the character of the driver, as such. Many men ill-treat their cars, and the purchaser of the same second-hand is buying trouble. For this very reason second-hand cars sell cheaply, and there are grand bargains to be picked up if the would-be purchaser can only succeed in separating the chaff from the wheat.

The Question of Price.

Many people complain that the prices charged for automobiles are exorbitant. Most of them have never seen a car made, and would wonder how it could be done for the money if they had the opportunity and patience to follow all the different processes through from beginning to end. It must be remembered, too, that in comparatively few cases are models sufficiently well established, either in the factory or by fashion, to justify their being turned out in very large quantities. As time goes on, doubtless cars will become cheaper; or, rather, while the prices remain much the same, the value given for those prices will be higher.

Except in the case where cost is no object, it is best to decide in the first instance on the sum proposed to be expended, then to hunt through some such list of cars as is produced by the leading automobile journals about the period of the annual exhibitions. This will lead to a number of makes being noted as approximately right in relation to seating accommodation, price, and (now that information on motoring is becoming fairly widespread) perhaps also speed and power. The number so chosen can generally be further reduced to four or five after consulting the illustrations and descriptions of the most recent models elsewhere in this Cyclopedia, and by referring to the good or bad results obtained in reliability trials, races, long-distance records, etc. The results of speed races are not much guide as to the excellence of a model, however, except the really serious races of great length, the winning of which may be looked on as proof that the factory has

a staff capable of designing, calculating and turning out a machine which can withstand the severe conditions of such a run.

Examination and Advice.

The next step is to visit the showrooms of the makers and use one's judgment, receiving with due discretion the necessarily favorable verdict which the salesman will pronounce upon his own product. At this point the real difficulty of choice comes in. If one has automobiling friends with en-experience and advice may sometimes be secured by consulting an engineer, but such a professional adviser must, of course, not be a dealer in, or interested in the sale of any cars.

It is unwise as a general rule to buy cars through the intermediary of one's own or a friend's chauffeur. It is preferable to trade direct with either the manufacturer or his agent, and, when there is a choice of agents, to buy from whatever local man is most likely to be called on to do the repairs afterwards. In either case it is often profitable to obtain and pay for skilled advice on the principle of the saying, "Advice that is not paid for is not worth having."

Every purchaser should, when ordering or buying a car, remember that he will some day want to sell it. This will often prevent the installation of some special "fad" which is the craze of the passing moment or the indulgence of some personal whim in construction which will surely detract from the selling value subsequently.

Buying a Second-hand Car.

In buying a second-hand car a very nice discrimination has to be used, for there are as many points about the second-hand automobile as there are about a stockyards horse. It is always best to obtain an expert's opinion before finally buying, unless the purchaser has already had sufficient experience to discriminate between a mechanism which has been fairly worn and one which has been torn about by bad driving and neglect.

Never buy a car because of its outward appearance; a coat

of paint will cover a multitude of blemishes, and it is not the finish which runs the car, though it frequently sells it to the novice. Often the result is that the owner pays for repairs in a few months a sum of money which, if added to the purchase price of the car, would have been sufficient to buy a new car. At the same time, a second-hand machine may prove an excellent educator in motor mechanics, and if the buyer happens to get hold of a really bad car, what he does not know about the details of an automobile and its tributary mechanism inside of six months is hardly worth knowing.

Examining the Frame—Having met with an apparently satisfactory vehicle, after a general inspection, the frame and wheels should first of all be subjected to a careful detailed examination. Many buyers are disposed to go for the motor and gearing alone, entirely neglecting the carriage work and frame, but as the latter has to carry the former, one should always go into that part first, so that an opinion as to the engine's capabilities of moving the vehicle can readily be formed. The stability of the entire machine centers itself upon the wheels, for no matter how good the rest may be, the whole is weak, from a traveling point of view, if the wheels are not strong enough to do the work they will be called upon to perform. Therefore, the first thing to do is to examine the wheels and their axles.

Supposing the wheels to be wood, the first tests should be for soundness generally. Grasp the rim of the wheel, and pull it towards and then push it forcibly away from you. If any give is felt or creaking heard, examine the wheel carefully to see that the spokes are tight at the hub and at the felloe or rim. If the wheel happens to have been built of imperfectly-seasoned wood, a shrinkage will probably occur, resulting in a loosening of the spokes at the felloe. More frequently the spokes are strained by inconsiderate driving over bad roads and unduly violent use of the brake many times repeated. Having tested all the wheels for soundness, next have them jacked up, and try them for wear in the bearings and for truth in running both circumferentially and laterally.

The chief test for axles is to find whether they have sunk or not; this is an easy test, for one has only to view the wheel edgewise and note if it is vertical or otherwise. If any doubt exists, a plumb line may be used. Pass a wheel which inclines outward at its top edge, but instantly reject it if it inclines inward, despite any plausible explanations from the vendor.

Springs and their Fastenings—Next examine the springs and their fastenings both to frame and axle. There is a big strain upon the shackles around the axles, and signs of springing here should be looked for. This is indicated by a cracking of the joint and an unmistakable line at the point of movement. Note that the springs lie flat upon one another, particularly at the joints. If they are apt to gape, they have been badly strained and the plates set back; the plates are therefore not doing their full share of the work, the greater part of it devolving upon the principal member.

Unsuspected Points of Wear—Points of considerable wear unsuspected and unattended to by many experienced automobilists are the bolts by which the springs are connected to the frame, particularly the free or linked end of the spring. When the car is in motion there is constant friction upon the top and bottom halves of the respective link bolts. Many owners have seen these bolts worn down by grooving one-eighth of an inch below the original diameter, and that after a few months' use. Much may be done to reduce this wear if the bolts are regularly oiled around the links and the eye at the opposite end of the spring.

The Steering Gear—The next part of the outfit to receive attention should be the steering gear. Anyone who has ever ridden in an automobile and given its operation a thought will at once realize the importance of having this as perfect as possible. The first thing to notice is the amount of backlash or free motion of the steering wheel or handle before the steering comes into operation. If the steering is of the worm and segment type, and the lost motion is found to be here, there is no radical cure for it beyond replacement. If it is on the combined screw, nut, rack and pinion type—that is, with a

nut working on a screw on the steering column, the former having a rack on it engaging with a pinion—adjustment is possible by the lock-nuts at the bottom of the steering column. If the looseness is not here it will probably be found in the connection of the steering and distance rods. If these connections are made with cone screws they may be adjusted, but if plain bolts are used it means fitting new bolts, at least, to correct the error.

Brake-applying Connections—Particular attention should be directed towards the braking arrangement, especially as to its adjustment, and to the range of the hand lever applying the back wheel brakes. Unless the brake-applying connections are correctly compensated both as to the equal application of power to the brake drums and to the relative movement between the carriage body and the back axle, it will be found that while the brake may be applied with sufficient force to stop the car while the body is up on the springs, yet when it is dcwn the lever canot be pushed down sufficiently to apply any appreciable power to the brake drums. This is because the slackness has to be taken up first by the hand lever before the band is applied to the drum. Unless sufficient travel is provided on the notched quadrant, it will be seen that with a heavy load the efficiency of the brakes is decreased under the very conditions at which it should be at its best. Sit in the car and put on the brake as hard as you can, and mark the notch in which the lever rests. Now load up the car and see how much further down the lever goes. Beyond this point there should be several notches, so as to make further application of the brake possible in contingencies. This latitude is noticeable in nearly every car fitted with cable-applied brakes, but is not so apparent in those using solid connecting rods. The pedal-applied countershaft band brake is not of so much importance, as it may easily be adjusted, and its conditions of use are not variable.

The Control Handles—Try the control handles, sparking advance, air to carbureter, and throttle if fitted; see if these are performing their various duties correctly and without too

much play. At the same time, note the relative movement of each part and its lever; that is, make sure of the position of the lever when, say, the spark is retarded for starting. It is useful to know these little things when running the motor later on. It must always be remembered that a certain amount of wear has been had out of a second-hand car, and that absolutely perfect adjustment must not, and need not, be expected.

Testing the Motor—This brings us to the motor. Much has to be taken for granted here, as it is impossible to find out the exact state of an engine short of taking it down, and it is hardly likely that any owner would consent to this, unless under very exceptional circumstances. However, some very useful information may be deduced by anyone understanding the running of a motor. For those who are unable to get any experienced assistance, the following tests may be carried out, supposing that a single-cylinder motor is being tried—the multi-cylinder we will deal with later:

First test the compression. Take the starting handle and turn round the crankshaft until decided resistance is encountered; then bear heavily upon the handle, noting the strength it takes to turn the handle until the compression stroke is passed. The longer the time and the greater the strength required to overcome this resistance the better the engine is as regards the fit and wear of the cylinder and piston. It must, of course, be seen that the valve lifter is down, or the compression relief is closed, otherwise no compression will be encountered. Another thing which will sometimes be found seriously to affect compression is that, through wear on the exhaust valve seating, the valve stem has got right down on to the plunger, so that it does not close down on to its seat perfectly. This and the proper fixing of the sparking plug and other cylinder fittings are obviously things to be attended to before carrying out this test.

Connecting Rod Bearings—The next test is for wear in the connecting rod bearings; this, in some cases, is very difficult to carry out. Where it is practicable to fix the starting handle,

or a long wrench to the crankshaft end, a gentle movement backward and forward will disclose any looseness in these bearings. Failing this test, the engine should be listened to very carefully while starting up, running slow, and stopping. If a distinct and recurring knocking noise is heard, it may very safely be assumed that the connecting-rod bearings are loose, and require taking up or renewing. If the gearing is inclosed and cannot be viewed, remove the contact breaker cover, and by moving the cam backward and forward a rough estimate of wear can be formed. If these wheels have been badly cut in the first place, the wear may amount to such proportions as would materially affect both the lifting of the exhaust valve and the amount of firing. Of course, the latter may be corrected by advancing the contact, but the late opening of the exhaust valve cannot be remedied without resetting the wheel on the shaft.

The Water Circulating System—If the motor is water-cooled, examine the water jacket for cracks, particularly around the head and valve chamber, where the jacket is cast in one with a solid-headed cylinder. When the cylinder and head are cast separately with their water jackets there is less risk of such cracks appearing. Attention should next be directed towards the water circulating pump, where such is fitted, and if driven by belt or friction wheel, the spindle should be felt to see that it is not too loose. It is as well to remove the stuffing box nut around the spindle, for at this point there is usually a lot of wear taking place, and it is just as well to know exactly in what condition the pump spindle is. It will probably save a lot of trouble later on. Look over the water pipes and connections. A badly-dented tube resists the passage of water, and, of course, affects the cooling of the cylinder to a considerable extent, that is, if it be a main delivery or return tube. The flexible connections of the water pipes should be of rubber hose, and should be free from leaks. It would be absurd to look at trivial points such as this with too critical an eye, yet beginners often make a trouble of a point like this, while they would say nothing about a lubricator

which would not work, simply because they did not know it was out of order. This is where the experienced man comes in.

Testing Ignition—The electric ignition apparatus should receive particular attention, as it is sometimes a little misunderstanding of this part which brings a really good car into the market. The most important part of the apparatus is the contact breaker or commutator. As there is a general misunderstanding of these terms, it will be as well to state their differences here. The contact breaker is a piece of mechanism in which two parts are put into contact with one another for a time, and are then parted. A commutator is a disk of insulating material having on its periphery metallic pieces in a like number to that of the cylinder. Bearing upon the disk is a brush of copper gauze, sheet copper, or steel, which, when the metallic pieces in the commutator pass beneath it, cause the current to pass. As the commutator is now perhaps more frequently employed than the contact breaker, we will use this term, but it must be understood that any remarks apply to both equally. The first thing is to see that the commutator is set correctly. To do this, relieve the cylinder compression, and turn the starting handle until the plunger rises to lift the exhaust valve; continue turning until the plunger drops. Now turn the handle round one revolution exactly, at which point the commutator should be about to come into action, that is, when it is set right back. Then move the sparking advance lever up, and note the amount of travel the brush has around the commutator; this represents the limits of ignition. A more definite method of finding the point of ignition is, when possible, to drop a stiff wire through the compression tap, letting it rest upon the top of the piston.

Batteries and Wiring—The wiring and all the connections should be examined most carefully, especially as to the cleanliness of the terminals and the soundness of the insulation around the wires. The chief points for inspecting the latter are at places where it bends round any part of the mechanism. At such places the vibration to which the wire is subjected frequently causes the insulation to be worn away, resulting

in annoying short circuits, and it is such defects as these which, as we said before, cause good machines to appear in the market. Where possible, look at the accumulator or battery plates to see they are not bent, as they may possibly be if they have been discharged too rapidly or too low. Also note at the same time if the plates themselves are complete; it sometimes happens that some of the paste falls from the plates, and if this happens to lodge between a positive and negative plate it sets up an internal "short," causing no little trouble.

Carbureter Efficiency—The carbureter should be examined to see that the air adjustment, float, and throttle valve (if fitted) work freely. Start the engine and while it is running slowly listen for any knocking or grinding sounds. Next, get a good mixture, and with the throttle full open gradually advance the ignition, noting if the engine answers to it well. Retard the spark, or cut off the current, and again listen for any knocks. When the engine stops, start it up again, and advance the spark about half or two-thirds of its travel, and then try varying the speed by means of the throttle valve. It will be as well at this stage to see that the cooling water has not become unduly heated, for if it keeps fairly cool while the engine is running with the car stationary, it will be certain to be more effective while the vehicle is moving. No indication of the power of the engine can be ascertained while the engine is running light.

Examining Multi-cylinder Engines—Up to the present we have been dealing solely with a single-cylinder motor, so we will now pass on to the extended tests required for a multi-cylinder one. Each cylinder should be tested for compression in the same way as previously described for a single-cylinder. The compression in each cylinder should be, as nearly as possible, equal. As the two-to-one gear wheels are usually of ample proportions, deterioration here may be regarded as a negative quantity. The ends of both crankshaft and camshaft being within easy access, these may be tried for wear, while the opposite end of the crankshaft may be similarly tried

by means of the flywheel. The examination of the commutator, as regards its position, is not of such great importance in this case on account of the reduced wear on the two-to-one gear wheels. The remainder of the mechanism should be inspected and tested in the same manner as for a single-cylinder engine.

The Lubrication—The lubrication of the engine is of the greatest importance, and this should therefore he looked to with a very critical eye. The methods of supplying lubricant are varied. In some engines the oil is passed through to the crank chamber in quantities by means of a force pump; in others it is supplied regularly drop by drop by a drip lubricator. These are the more useful methods. With the force pump lubricator it is sufficient to see that the pump is acting correctly, and that its piping is complete and not leaking at any joints. In the drip feed lubricator a more careful examination is needed, as there are adjustment details to be looked to, for it is most important that the feed be regulated to suit the fluid conditions of the oil. If the drip valves are found to act correctly, then look over the pipes for dents or fractures. The pipes should in this case be of fairly large diameter, so as not to interfere with the free flowing of the oil. There are a variety of mechanical oil feeds fitted, and these should be noted for correct functioning while the engine is running.

Transmission Considerations—We next arrive at the transmission gear, but this we must deal with very broadly, as there are so many adaptations of the various systems. The first part of the transmission is the clutch. With the hand, depress the clutch pedal and see that the driven portion is withdrawn clear of the driver without any excessive force being used. In the case of leather to metal clutches, if the male cone can be withdrawn sufficiently to examine the leather facing, it should be seen if this is in good order and not worn down too thin. While the male cone is out of engagement the clutch-shaft should be tried for wear by lifting it at the cone. It

should also be noted that there is provision made for adjusting both the clutch and the clutch pedal.

The Change Speed Gear—It will be necessary to lift the lid off the gear-box to inspect the change speed gear wheels. The teeth of these wheels should show a brightly burnished surface on the faces, but not on the tops and bottoms. By faces is meant the breadth of the teeth which engage with the opposite wheel. If they show as brightly at the tooth bottom as they do on the faces, they have been intermeshed too deeply in the first place, and there is likely to be excessive wear. If they show dark or lightly touched surfaces, they have been correctly set, and they should be in good running order; in fact, they will probably be better than new. Each of the wheels should be looked at all the way round to ascertain that no teeth are broken. If the sliding type of gear—that is, a type where the wheels are slid into engagement sidewise—be in the car under notice, the edges of the teeth should be looked to. If the car has been in good hands, the teeth will show brightly on their engaging sides; but if the driver has been at all clumsy it will probably be found that the teeth are badly chipped at these points.

The speed changing movements should all be closely watched while manipulating the actuating lever. The wheels on the sliding sleeve should move deliberately and accurately into their corresponding wheel—that is, provided the teeth are not opposite one another. The edges of the wheels should be in a perfect line, not one overhanging the other; if this is the case, it indicates a lot of lost motion in the connections between the sleeves and the actuating lever. A certain amount of latitude is permissible here, but the movement should not be more than what might be termed "a little free." If there is a lot of backlash there is something wrong somewhere, and it should be carefully looked for with a view of correction. If the total width of one wheel exceeds that of the other, as is sometimes the case, particularly with the reversing gear, then it does not follow that something must necessarily be wrong.

Points of Strain and Wear—The bolting up of the gear-box

to the frame also should be inspected, particularly for signs of straining. Its oil-retaining and dust-excluding capacities should be attended to, otherwise trouble is likely to follow. After the shaking up of a few thousand miles the lid of the box sometimes develops a tendency to rattle by reason of the catches working loose; where studs or bolts and nuts are used for this purpose, there is no fear of the lid coming adrift.

The countershaft bearings and differential gear should be looked to and tried as far as possible, and side chains, if any, carefully inspected. These and the sprocket wheels should be examined most carefully, as they are the last stage but one in the chain-drive transmission system, and, moreover, often have to run entirely exposed. Hard, gritty, sandy mud acts as an abrasive upon both chain and sprockets, cutting them about very badly, if the car has had much running in bad weather in sandy districts. The forward or wearing side of the teeth is likely in time to become concave in form instead of convex, thus interfering with the chain leaving the wheel freely. As to the chains, the principal parts are the side links upon which the greater strain comes. If these appear to be cut or distorted and want renewing, it should have an effect on the price of the car.

The propeller-shaft joints, bevels, differential gear and driving ends of the rear axle should all be tested for play. How to do this will be found under Overhauling in the paragraphs on the Differential Gear and Live Axle.

Wear and Tear Considerations—It should always be borne in mind that one must discriminate between fair wear and tear and bad usage. The results of fair wear and tear will always be found in a second-hand car and cannot very well be objected to, but results of bad usage should be noted as likely to cause future trouble. In such parts as the steering gear, governor, carbureter, ignition system and other connections there will usually be some looseness due to use, and allowance must be made for this. It is only excessive wear, the result of misuse, or bad fitting, that needs careful examination be-

yet (which is far the more common fault) not of too small a diameter, as the running costs due to bursts then become prohibitive.

Choice of Track—See under Driving.

Chopper Switches—Switches used in magneto ignition for cutting out the cylinders for testing purposes.

Chromic Acid—A red crystalline compound ($H_2 Cr O_4$) derived from chromic anhydride. It is used in connection with primary cells for charging batteries. The zinc element of the cell is immersed in a solution of chromic acid.

Chromium—A metallic element obtained pure as a light green crystalline powder. It is largely used in the arts and in the form of voltaic cell called the bichromate cell. Also used in making chrome leather, utilized for anti-skidding devices.

Chuck—A part of a turning-lathe used to fix the work in order to turn it into any desired form. Chucks are of various kinds, including spur-chucks, shell-chucks, universal chucks, etc. A simple chuck can communicate only the motion round an axis which it receives itself; a combination chuck is one with which the axis of the work can be changed at pleasure.

Cinematics—Also Kinematics. The science of motion; that branch of knowledge which treats of the direction, velocity, acceleration, etc. Applied cinematics is the theory of mechanical devices for converting one kind of motion into another, as when a reciprocating piston-rod transmits a uniform rotation to a wheel.

Circle, Pitch—The circle which would bisect all the teeth of a toothed wheel. Also written Pitch-circle and sometimes called Pitch-line.

Circuit—The path which a current of electricity takes in passing from one pole of the battery to the other. See Ignition.

In a voltaic battery the circuit is composed of the metallic plates in the cells, with the liquid in which they are immersed,

together with the conducting wire or other conductor joining the two poles of the battery. When the path of the current is complete the circuit is "made" or "closed." When there is an interruption at any point the circuit is "broken" or "opened."

Circuit Breaker—A mechanical device for breaking or "opening" an electrical circuit. In charging storage batteries an automatic circuit breaker is often used to regulate the voltage. See Contact Breaker.

Circuit, Broken, Testing for—See under Ignition.

Circuit Ignition—See Ignition.

Circuit, Make and Break—See Contact Maker.

Circuit, Short—See Short Circuit.

Circulating Pump—See Pump.

Circulating System, Clearing the—See under Circulation.

Circulation—The term often applied to the water-cooling system in connection with motors.

In typical modern systems the tank and radiators are combined. The water flows as follows:

1. From bottom of radiator to bottom of water jacket.
2. From top of water jacket to top of radiator.

In this system the pump (when one is used) is placed between the bottom of the radiator and bottom of water jacket. When the tank and radiator are independent of each other the water flows as follows:

1. From tank to bottom of water jacket.
2. From top of water jacket to radiator.
3. From bottom of radiator to tank.

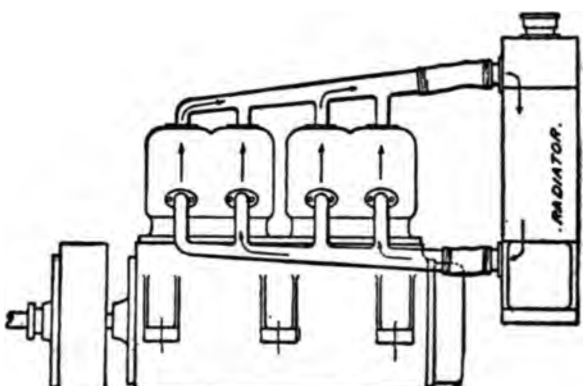
In this system the pump (when one is used) is placed between the bottom of water jacket and tank.

A fan is generally fitted to increase the air draught and assist in the cooling. See Air-cooling, Fan, Repairs and Adjustments.

In gravity or so-called thermo-syphon feed no pump is used, but the tank is placed above the water jacket, and the cool water flows into the bottom of the jacket. As it is heated by the engine it rises and, emerging from the top, finds its way

through the radiator back into the tank. Gravity feed is simpler than the pump feed, but not quite so efficient. In this system the speed of the circulation is directly affected by the difference in temperature between the water in the tank and the water in the cylinder jacket. This difference can be increased and the speed and circulation also increased by the use of a rotary engine-driven fan behind the radiator.

Radiators in gasolene cars are used, as their name implies, to radiate the heat away from the water which has absorbed the heat from the cylinder walls. The water is circulated from

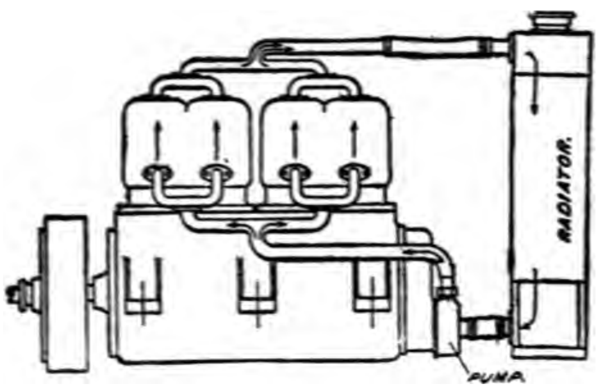


"Natural" Circulation, Without Pump, or Thermo-Syphon.

the engine cylinder through the radiator and back again by several systems, in one of which the radiator itself becomes the circulating medium. The great object in the construction of every radiator is to obtain as large an area of surface exposed to the air as possible, in proportion to the amount of water present in the appliance. An ideal radiator would be an infinitely thin chamber with large flat sides of enormous surface, with a current of cold air sweeping along them, but, as such a design is impracticable in motor car work, it is necessary to construct appliances which approximate as near as possible to that condition.

Thus, if we have water flowing through a very thin tube of good heat-conducting material, such as copper, we can in-

crease the radiating effect by mounting upon the copper tube, and in intimate metallic contact with it, a number of fine ribs or gills of metal which in themselves form additional surfaces for the radiating away of the heat. If, in addition to this, we can put this appliance in a position where a constant stream of cold air will pass across these gills the radiating effect will be still further increased. In the older type of radiators this was practically the principle adopted and, in order to get a very great length of these pipes, they were formed into a kind of square bundle placed in front of the car, the water circulating right around through the whole series of pipes one after the other.



Forced Circulation of Water by Pump.

In more modern practice the honeycomb radiator has been adopted. This consists of a tank containing the water to be cooled, and having threaded through it innumerable honeycomb shaped tubes through which the air can pass, the water lying in extremely thin layers between all the adjacent sides of all these tubes. This type of radiator is placed directly in front of the car, so that the air can pass right through it, the air current being accelerated by the forward motion of the car itself. In order to increase the air current, however, in many cases a fan is placed behind the radiator, and driven by the engine, thus drawing a constant current of cool air through the tubes. There are other modifications of the honeycomb

radiator used, but the principle in all is precisely the same; that of subjecting very thin layers of water to large radiated surfaces.

In the honeycomb radiator the cooling effect is so great that a very small quantity of water may be used, this water being kept constantly in circulation through the engine cylinder jackets and the radiator. This circulation must in most cases be induced, in which case a pump of some kind is used. (See Pumps.) The pump is driven from the engine by suitable gearing, and keeps a constant flow from radiator to cylinder, and vice versa. In some cases, however, where very efficient radiators are used, and where single-cylinder engines are fitted, the circulation may be by natural means. In this case the radiating tank must be fixed at a level higher than the cylinder, so that the hot water in the cylinder may rise to the top of the radiator, its place being taken by the cold water which flows from the bottom of the radiator to the bottom of the engine jacket.

In the case where pumps are employed to circulate the water it is not a matter of much consequence whether the radiator is placed above or below the engine, as the positive circulation caused by the pump is sufficient to keep the water constantly flowing. In some cases, as where the gilled tube radiators are used, it is necessary to have a separate water tank, as the amount of water in the tubes is not sufficient. In this case the tank may be placed in any convenient position on the car, and the circulation is, of course, by pump. In this type, too, the radiator may be placed behind the car or underneath, where it gets a very strong draft of air which passes along underneath the car body.

The direction of the circulation of the water through a radiator should always be that in which the hot water coming from the engine enters the radiator at the top and passes out in its cooled state at the bottom. In the case where a tank is fitted it is advisable to draw the supply of water to the bottom of the cylinder direct from the tank, taking it out of the top of the cylinder down through the radiator, back to the top

of the tank. In this case if the pump is one of the centrifugal type, it should be placed on the pipe leading from the tank to the engine. If, however, the pump is of the direct gear-driven type, it may be placed anywhere, but it is advisable to place the pump in that section of the circulation in which the water is likely to be coolest, as the efficiency of the water pump is considerably decreased as the temperature of the water it has to circulate rises. (See Pumps.)

A Few Physical Facts.

A few physical facts about water at the temperatures which occur on motor cars may be stated:

First: Cold water is heavier than hot water, therefore cold water falls to the bottom of a hot water tank or radiator. Reciprocally, hot water flows to the top of a water space such as a cylinder jacket, without the help of any pump. The difference of weights and volumes of hot and cold water is easily ascertained. It is this difference of weight which causes the flow.

Second: If suction be applied to very hot water, say on the verge of boiling, in a pipe, the water will not move in the direction of the suction, but a steam bubble will develop. Scientifically stated, water boils at a lower temperature when the pressure is lowered.

Third: Narrow pipes offer much resistance to the movement of water. Sharp bends offer still greater resistance.

Natural Circulation—From these facts we see that if the pipes be large and smooth with no sharp bends, or if the bottom of the radiator be high up compared to the cylinder water jacket, no pump is needed. This is called "natural circulation."

Forced Circulation—From the same three facts it appears that when forced circulation is used—

1. The pump should be so placed that its suction is connected to the coolest supply of water available.

2. The pump should be low down so that the water flows by its own weight into the suction side of the pump. All the water in a car is generally fairly hot after a short run.

3. The pump should deliver water at the bottom of the water jackets so that the natural flow upwards of the water as it gets hot will not be opposed to the action of the pump.

4. The outlet of the water from the cylinder should be to the top of the radiator, as the cooling effect of the radiator will cause the cold part of the water to fall down to where the pump suction tube is placed.

It is to be noticed in both systems that the utmost importance attaches to the arrangement of pipes being such that all the cylinders get their full share of water, and no one cylinder more than another. For this reason, with natural circulation, the horizontal pipes are very carefully designed to taper sufficiently to throttle back any undue flow from one cylinder and encourage a proportionate flow in each.

Water Circulation Hints.

Rubber Joints—Owing to the slight separate movement of individual cylinders or individual pairs of cylinders, there is a tendency for the water pipes, if of metal throughout their length, to break by the continual vibration. Hence in some designs the pipes are cut and rubber joints are used, especially on the pipes from the upper end of the cylinder. See Water System Connections below.

The specific arrangement of parts in some cars renders it necessary to depart from what might be called the standard direction of water flow. Thus in some cars the pump, which is placed very low, draws its supply by gravity (without needing to exert any suction) from the bottom of the water tank, and delivers it to the engine jacket in two streams; one stream passes by the combustion head to the bottom of the radiator; another stream passes through the jacket on the lower part of the cylinder, and thence to another connection on the radiator higher up. From the radiator the water flows to the tank and thence back to the pump, thus completing the circuit.

Airlock—When the water-cooling system of a gasolene engine has twists and kinks in the pipes, as in some designs, it sometimes happens that on filling up with water an air bub-

ble forms in the top of a bend, and owing to the air being extremely elastic, this bubble merely gets compressed instead of moving along when the water-circulating pump begins to operate. This effectively means no circulation, with consequent rapid boiling away of that portion of the water which is permanently in contact with the engine, and is locked out from access to the coolers or radiators.

Airlock is cured usually by drawing off the water and continuing to fill up the tanks while the engine is running. Also a special plug is provided in the top of many radiators to let out the air. The existence of airlock or stoppage is to be discovered very easily by feeling the top and bottom of the radiators with the hand after the car has run a mile or two. If the top and bottom are at a very different temperature there is either airlock or the pump is not acting. See Air Lock.

Leaking Pumps.

There is nothing more annoying or more difficult to deal with than a water-circulating pump which persistently leaks. Such a pump is almost hopeless, as the defect can usually be traced to faulty designing, the bearings not being long enough. When this is the case, the pump being rotated by chain or by frictional contact with the flywheel of the engine, the driving pressure being applied at one point causes the pump spindle to bear against opposite ends of the bearing. Now, the shorter the bearing is the greater the wear will be, and so soon as this reaches an appreciable amount, a permanent leakage will occur. This can only be cured by rebushing, fitting stuffing box glands, or relining the bearing—an expensive job, which would have to be repeated at very short intervals. The moral is, If you have a bad pump, get rid of it at once.

Instead of a long plain bearing, many pumps are fitted with a stuffing box and gland. Asbestos, tow, or other material is packed into the stuffing box, and the gland is tightened up to make a water-tight joint around the revolving spindle. Even the best of pumps will leak in time through the bearing wearing. When this occurs, the best packing to use is one com-

posed of alternate rings of rubber and hard fiber, which should be a good fit over the spindle. If the pump runs at too high a speed for the rubber rings to stand up to, then alternate the fiber rings—which should be at least one-eighth inch thick—with asbestos cord.

Combined Systems of Circulation.

Although many object to natural water circulation, it is a wonder that the compromise between forced and natural is not more often adopted; some well-known cars possess this feature. It simply amounts to arranging the radiator so that a considerable portion of the water is carried above the engine level. This and the proper disposition of the circulating pipes, of course on the assumption that sufficient area of radiator is given, will enable one to run quite satisfactorily with the pump out of gear. The water boils away quickly, and must be frequently renewed, but it is possible to continue to drive. With a system in which practically the whole of the water is carried below the engine, nothing can be done unless the pump is at work. Nowadays, pumps give very little trouble indeed, though they used to be a considerable source of annoyance. It is well to know the defects of one's pump, and to have the necessary spare parts or duplicates at hand in case of a delay sooner or later. If the cessation of the pump is not noticed till such time as the engine gets violently overheated, no attempt should be made to fill up the tank again until the engine has cooled off. In extreme cases it will be found that when the current is switched off the engine will go on firing. If this is so, the throttle should be instantly closed, as every revolution which the engine runs at this heat is dangerous. If things get to this stage, no water should be put into the tank for at least twenty minutes.

Water System Connections.

Those car owners who have trouble with their water connections should substitute wire armored rubber hose for the metal pipes, making the joints by binding round with copper wire; or, better still, using proper clips, which can be bought

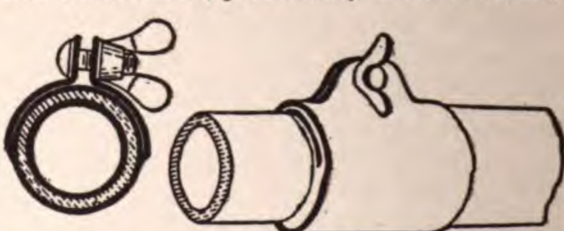
for the purpose. The rubber hose accommodates itself to vibration and curvature, and, consequently, strains the unions but little. See Rubber Joints above.

Breaking of Water Pipes.

From time to time complaints are made of the breakage of water-pipe connections at cylinder tops. On investigation it is usually found that this has taken place in two, three, or four-cylinder engines when the cylinders have been cast separately. No doubt the reason has been the fact that some slight deflection between each cylinder takes place, and as copper pipes are usually sweated into the elbow or T castings they pull away at this point, thus allowing leakage to take place. If any car owner experiences this trouble, the best way to get over it is to saw the copper pipe in two halfway between each cylinder, and then fit thereon a rubber connection, which is clipped at either end to the copper pipe. It will be found that no further trouble will be experienced.

Clamping Rubber Tubes.

The method adopted ordinarily for fixing rubber hose to the copper tubing in connection with the water-cooling system is more or less troublesome, particularly when it becomes neces-



sary to disconnect any of the rubber tubing for repair purposes, or in order to gain access to another part. A more simple method would be to use a special clip. The use of an ordinary clip is not satisfactory, inasmuch as when the clip is tightened up it has the effect of pinching up the rubber pipe at the clip joint, pulling it away from the water tube and creating a serious leak. However, by placing a semi-circular

piece of metal over the pipe and the clip around it, a firm metal grip is obtained, embracing the whole of the rubber tubing, and pinching of the tube or leakage is prevented

To Stop a Leak in the Water-cooling System.

Bind around the part leaking a length of string which has previously been soaked in oil to make a satisfactory temporary repair. The string should be soaked in boiled linseed oil for preference, if one happens to be in a locality where this can be obtained; or, failing this, thick lubricating oil. Then wind the string round the joint, keeping the coils as close together as possible. The start and finish of the coil should be some little distance on each side of the point at which the leak occurs. The winding should consist of two or three layers of string, if plenty of this very useful material is at hand.

In the case of a leak occurring in the tank, if the fracture is sufficiently large, some tow can be made by picking a piece of string, soaking it in oil, and packing it into the joints by means of a chisel or a strong blade of a penknife. White lead, of course, is at all times preferable to oil, where procurable, and if a piece of tape can be used in conjunction with this a satisfactory and permanent repair can be effected.

Repairing Leaky Radiators.

In the case of a leaky honeycomb radiator—that is, when the leak proceeds from a fault in one of the tubes—the best way temporarily to staunch the flow is to spread some white lead upon a strip of linen and tamp the tube with it, filling up the tube nice and solid, and smearing the white lead well over each end. The white lead will dry and harden, and effectually stop the leak until a more permanent repair can be made. Leaks in honeycomb radiators are also quickly and effectually stopped by the use of a patent plug, consisting of two little flat plates faced inside with leather, one plate carrying a short length of spiral spring with hook at the free end to attach to the loose plate. A draw wire is provided to stretch the spiral spring through the tube and attach the inside plug. The spring

draws the leather faces of the plates hard up against the ends of the tube, and stops the leak.

Other Methods—Leaky radiators are not a common complaint, but as they do occasionally occur, the recital of the means adopted by one autoist to overcome a badly-strained tubular radiator will be of interest. At the time of the occurrence his route took him over some exceedingly lumpy byroads, which, despite good springs, had such a vibratory effect on the radiator that no less than six of the vertical tubes became loose in the lower tank to such an extent that the water flowed freely from them. The first intimation of trouble was overheating of the engine and steaming at the radiator filling cap. He found the radiator fast emptying itself from unexpected vents. There was nothing for it but to drain the tank, which was done. Then, drying off the water from the tubes, he procured a canful of water from a neighboring hotel, and filled up again until he had located the faulty tubes by watching the water run from the fractures, which all occurred at the soldered joints to the lower tank. Time and circumstances did not permit of having the joints resoldered, so he procured some white lead, and smearing this on small pieces of rag, laid them round the fractures, previously dried and cleaned, binding each tube round with string, so as to force the coated rag downward on to the tank. When each tube had been so treated, the radiator was filled up with water to test the joints, which were found satisfactory, and packing was introduced at suitable points to brace up the radiator. The journey was continued, and between thirty and forty miles traversed without the loss of more than half-a-teacupful of the cooling fluid.

Spring Drive Belt for Fan.

Often trouble is experienced with the leather belt fitted to drive fans. This can be totally eliminated by fitting a steel spring belt having an outside diameter of from one-half inch to five-eighths inch. With such a belt, no adjustment is necessary, for the slight tension placed thereon when first fitted is sufficient for all practical purposes, and it has the advantage

that very little wear takes place on the fan bearings due to the pull of the belt. To obtain a quiet drive with this belt, it is necessary to arrange the belt pulley groove at a very sharp angle, otherwise the belt has a tendency to bottom thereon and cause a noise at every variation of the engine speed.

To show the efficiency of this spring drive, it is only necessary to say that in cases where a small dynamo is used for generating a constant current to feed storage batteries and light lamps, the spring drive has been found to be quite satisfactory, and very little slip takes place between the driving belt and pulley.

Clearing the Circulating System.

The water-circulating system may be cleared of impurities after running with dirty water by filling up the tank with a strong solution of soda. Run the engine for a few minutes, and draw off the soda water; then wash out with clean water. In making the soda solution as much common house soda as the water will dissolve should be used.

Fouling Radiators.

Whenever possible, rain water only should be put into radiators, particularly cellular radiators, in which the water spaces are hardly thicker than a good stout sheet of wrapping paper. Short of rain water, river water is best, but water from wells should be shunned, as it generally carries a large percentage of lime in suspension, which is precipitated by the heat and thrown down upon the inner surfaces of the cylinder jackets and the radiator tubes in a hard layer, which thickens every day, particularly if the radiator loses much or leaks, and so requires frequent replenishment. When the furred coat amounts to any thickness, the engine will run much hotter than before, as the deposited layer is a very bad conductor of heat, and so the evil continues to grow. Experience has shown that deposits 3-32 in. to 1-16 in. thick on the jacket walls cause a loss of heat value equal to thirteen per cent, 3-16 in. thirty-two per cent, and so on. It will repay any car owner who owns a garage or car shed to gutter it, and lead the rain-

fall into a butt or tank for use. If plenty of rainwater can be caught and stored, it is much better than hard water for body washing.

A Useful Water Strainer.

A useful and easily-made water strainer may be made in the following manner: Take a metal ring or a piece of wire bent into a circle, and stitch on to it a long, conically-shaped bag made out of old linen. The ring should be sufficiently large to rest upon the edge of the water filling pipe, the bag dropping well down into this. If circumstances permit, it may be left in position, simply screwing the cap covering the filling pipe into position on top of it. Thus one has the strainer in position, and it will obviate all possibility of any foreign matter being taken into the water tank or the circulating system. It is a simple thing, but it guards against all possibilities of getting the pump choked, the water circulation stopped, and the engine overheated, and consequent damage and delay.

Steaming at the Radiator.

One should observe how hot the cooler gets in the ordinary way, and also whether any steam is given off, because then, if any noticeable increase of heat or steam occurs, one may immediately conclude that the water circulation is failing, and attention will be given to the point at once. The chances are that the pump is the cause of the trouble. It will either have become deranged in itself, or, what is more likely, it will not run through the friction wheel or other means employed to drive it, having temporarily failed through some trifling cause. This applies to cars with large radiators not depending at all upon forced draught. With machines which are fitted with a fan, the extra heating may, of course, be due to the belt or chain of the fan having come off. One can always tell whether the pump is working by the pressure gauge, if one is fitted. If there is no instrument of this kind, and many cars are without it, it is easy enough to see whether the pump is throwing by opening the cock while the engine is running. If the water is thrown with vigor, no anxiety need be felt as to the healthi-

ness of the circulation. This cock must be made a tight fit, as trouble has often occurred owing to its having shaken open. This will allow the water to drain away and so cause great damage to the engine.

A Typical Modern System.

The modern system of water-cooling used in the Locomobile is described as follows:

"The water used to cool the motor is circulated by a powerful centrifugal pump, the revolving blades of which are

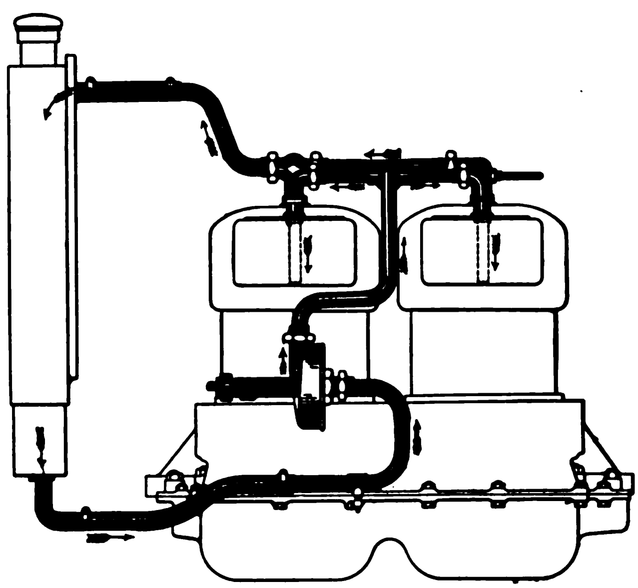


Diagram of Locomobile Water Cooling System.

mounted on a shaft driven by a gear meshing with the exhaust cam-shaft gear. This method of driving the pump is absolutely positive and the entire apparatus is as reliable as can be devised. As will be noted from the diagram, the pump draws the water from the radiator and forces it upward to the cylinders, whence through vertical stand pipes it is carried clear to the bottom of the water jackets, thus insuring a thor-

ough cooling of the cylinders. The hot water from the motor then passes to the radiator, where it is cooled and delivered back to the pump. In the diagram the arrows indicate the direction of the circulating water. The cellular radiator is of ample size, highly efficient, light in weight, and extremely attractive in appearance; it rests in a flanged cradle and is securely bolted thereto, a method of construction which eliminates any racking action on the joints, and consequently any tendency to produce leaks. The radiator is placed a little back of the front axle, instead of hanging out over it, thus giving a neat and stylish appearance to the complete car.

"A pressure gauge is placed on the dashboard in view of the operator, and indicates a slight pressure when the car is running; if the clutch be released temporarily so as to speed up the motor, the pressure gauge will register several pounds, thus indicating that everything in the circulating system is in a satisfactory condition. When no pressure is registered it is an indication that the gauge is out of order or that some part of the system needs attention."

City Traffic, Driving Through—See under Driving.

Clack Valve—Otherwise Ball Valve, Check Valve or Non-return Valve. See Valves.

Clamp—A wooden or metal arrangement for holding two parts together.

Clamp, To—To firmly hold two parts together mechanically. To repair a fracture by securing the parts to each other by suitably-shaped iron plates, held together by bolts or other means.

Clamp-dog—A clamp used to connect the article or piece to be turned and the spindle of a lathe, so that the work partakes of the motion of the head-spindle.

Clamp-screw—A tool used to hold joiners' work to the table or to hold two pieces tightly together.

Clamping-piece—A suitably-shaped piece or pieces of metal which rigidly hold two parts together. The engine is some-

times said to be clamped to the frame by means of lugs or projections and bolts.

Two iron plates of suitable shape between which a fractured part is held by means of bolts is also known as a clamping-piece or cramp.

Claw—A claw is a member which takes its name from being shaped something like an animal's claw. It is generally used to engage two shafts, and then forms what is known as a claw coupling. Instances of its use are found in the coupling of those shafts which drive magnetos and pumps to the spindles of the latter. A claw coupling proper does not actually connect the shafts together—they are held in position in their bearings—but the claws are so arranged as to come in contact with each other so that one shaft is driven by the other. It allows of the pump or the magneto being disconnected without undoing any actual connection between the two shafts.

Claw Coupling—See Claw.

Cleaning—Proper care of a motor vehicle requires that it should be kept as free from dirt as possible.

The vehicle as a whole should be thoroughly cleaned after a run and the body washed, either by means of a hose with a slow running stream, or by pouring water over those parts which require such treatment by means of a watering-can, a sponge, etc. A forcible jet of water from a hose has a very bad effect on the paint, as it tends to drive any particles of grit into the surface of the varnish, thus destroying its luster. The same applies to dashing water violently from a bucket on to such painted parts. After thorough washing, the water should be dried up by means of a soft sponge and then the whole polished with a soft chamois leather. Particular attention should be given to corners and crevices, and any water which may lodge there should be absorbed, and such parts well dried.

As to the metallic parts, the best treatment for these is to go over them with a painter's brush and kerosene, afterwards

wiping the parts so treated with a soft cloth. If gasolene or turpentine is used for cleaning purposes, care should be taken to keep it clear of all paint work, as these liquids have the property of dissolving paint or varnish. The tires should be wiped clean and dried. See that they are well inflated and that no water gets in to rust the rims and rot the canvas.

Cleaning Brass Lamps.

The following plan is a good method of cleaning brass lamps without much labor, having proved very efficacious even where they were green with verdigris and in a shocking condition: Make a mixture of brass polish and wood alcohol until it forms a paste of the consistency of cream, when it can be applied with a paint brush. The lamps should be left for two or three days, if convenient, and the paste cleaned off with an oily rag. The paste, verdigris, and dullness come away without any rubbing, leaving the clean brass exposed, which requires merely the usual brisk polishing to restore it to its former brilliance.

Preparing Brushes for Cleaning Cars.

Not many owners of cars like the operation of cleaning them, this generally being left to some handy man or the regular chauffeur, where one is engaged. Fewer still know how to use a cleaning brush so as to obtain the best results, and make such brush last the longest time possible. When a new brush is bought the usual plan adopted is to put it to work at once, but this is not correct. The better way is to soak it in a bucket or tub of water for a couple of hours. This softens the bristles, and also swells the wood. Then the brush should be taken out of the water and allowed to get nearly dry, but not quite, it being left in the shade during this time. Then it can be used with the certainty that it will shed fewer bristles than if it had been at once put to work. It will be found that if this tip is adopted the cleaning brush expenses will be reduced very considerably.

Cleaning Enameled Leather.

Enameled leather wings, hoods, or aprons should always be washed with weak soap and water, after which they should be carefully dried off and then polished with a chamois leather, On no account use oil, as so many people are apt to do, as this has a softening effect on the enamel, which in time causes it to deteriorate and lose its polish.

Cleaning the Piston and Rings.

When the insides of the piston rings are examined, and also the grooves in the piston, probably a hard deposit of burnt lubricating oil or other caked substance will be noticed. This can readily be removed from the rings by rubbing the safe or smooth edge of a file round the inner side, care being taken not to scratch or raise an edge on the sides of the ring; a narrow and sharp screwdriver will remove the deposit from the bottoms of the piston grooves quite readily when once the surface is got under, as the matter is very brittle and will curl off when the screwdriver point is used like a scraper or chisel. A previous soaking in kerosene for half an hour will loosen the deposit, and also all the oil from all parts of the piston and rings. As the rings are taken off, it would be as well to mark them by nicking slightly on one edge with a fine file, so as to insure that they are put back in the same groove that they were taken from, as they may not work exactly the same if the position is changed. The top ring could be marked with one nick, the second ring with two nicks, and so on. Also scrape any deposit from the piston top.

Piston rings should be carefully handled, as the good running of the engine largely depends on their correctly fitting the cylinder and working perfectly free without play in their grooves.

Cleaning Cars and Parts—See additional matter under Care and Maintenance.

Cleaning Gas Reflectors—See under Useful Information.

Cleaning Gas Tubes—See under Useful Information.

Cleaning Grease Pipes—See under Lubrication.

Cleaning Motor and Other Machinery Parts—Deposits of carbon have been the cause for many of the troubles of the motorist; nor have the makers of motors as yet so perfected their wares as to entirely avoid this trouble. Carbon comes from poor lubricating systems, which are not thorough enough in their functions and which, as a result, compel the motorist to take the safe course and overlubricate rather than underlubricate, saving bearings and fouling the engine. The oiling system of the present-day motor car is receiving the attention at the hands of the makers which it should have received some years ago. It is also true that now lubricating oil makers better understand what is needed, so that, all in all, the troubles that have existed are being eliminated.

Carbon deposits cause pre-ignition, overheating, warped valves and valve stems, poor compression and consequently loss of power, inability to secure a correct mixture and other ills. It is essential that the cylinders be free from carbon if it is expected the motor is to do its best work.

Cleaning Cylinders.

There are preparations made to remove carbon and great claims are made for them by their makers and in some instances by their users. Others stick to kerosene and claim good results. As a matter of fact such things are not needed if the lubricating system is right. The real way to clean a cylinder is to scrape it and unless the valves are in the head it will necessitate the removal of the cylinder from the crankcase. Some valve-in-the-head motors are so made that the removal of valve cages will permit sufficient access to the combustion chamber as to allow their being cleaned. In this case the piston should be a little way down from the top, a handful of waste should be packed in the cylinder to catch the falling pieces of carbon, and an old flat file should be bent over half an inch at the end, sharpened and slightly rounded. Then all parts of the cylinder can be scraped. Care should

be taken that the scraper does not touch the cylinder walls and scratch them. After all the carbon has been removed—all that is possible to remove from combustion chamber and top of the piston—a cloth saturated with kerosene should be rubbed over the cleaned parts to remove the fine pieces remaining. Kerosene will aid in softening the carbon and can be used to advantage before scraping. It is the habit of some motorists to use kerosene once a week to remove carbon. It is a remedy of doubtful efficacy. It is like taking medicine all the time. Remove the cause and there will be no need for the remedy.

Cleaning Crank-Case.

Under the terrific heat produced by a gasolene motor, the oil in the crank-case soon loses its lubricating qualities and becomes so much black dirt. Once a month at least the old oil should be drained from the crank-case, the case washed out with a cloth saturated with kerosene and wiped dry. Do not use waste, as the ravelings will stick to the rough parts of the casting and may become entangled in the cam shaft gears. Besides, it is wise to look at the bearings of the motor once in awhile to see that a cotter pin or some other piece of metal has not settled in the bottom of the crank-case, only to be caught in the gears to do damage.

Cleaning Clutch.

Disk clutches require attention; perhaps not more than cone clutches, however, but in another direction. The disk clutch should be washed with kerosene; in fact, the kerosene should be permitted to stand on the plates a couple of hours. Then gasolene should be used to wash out the kerosene. After the gasolene has had time to evaporate, the clutch should have its usual supply of oil.

Cone clutches need to have the leather surfaces cleaned with gasolene once a month, so that the oil from the motor will not become saturated in the leather. After being thoroughly cleaned and dried, they should be given an application of castor oil.

Transmission and Differential.

Both the transmission gears and the differential gears should receive frequent attention and be cleaned and new lubricant put in. In some cars fairly heavy oil is used in both the transmission and differential cases. Naturally this oil loses its lubricating qualities, wastes, becomes gummed and any metal wearing off of the gears settles at the bottom. Where oil is used it should be drained off and kerosene run through to wash out any substance that might stick. Then new oil should be put in.

Where grease is used, this too becomes gummy and should be cleaned out occasionally and replaced with new material. Grease, however, will not require replacement so frequently as oil. As a matter of fact, a non-fluid oil is far better to use in either case than oil or heavy grease.

Cleaning Axle Bearings.

Most axle bearings are packed with non-fluid oil or grease, which wears away, becomes gummed and more or less dirt adheres thereto. Once in a thousand miles or a little over the wheels should be removed and the bearings thoroughly cleaned of all grease or oil by the use of gasolene and a brush. At this time an inspection of the axles and bearings should be made and any needed replacements made. The bearings should be repacked with lubricant and readjusted; then it will be found the car pushes much easier than before.

Cleaning Brake Linings.

When the wheels are off to be cleaned, the brake linings should receive attention, too. These can be cleaned by the same method, but the supply of gasolene should be more liberal as dirt and grease will be found to be soaked into the brake linings and they will require considerable soaking to remove the deposits. It is more than likely the brake adjustments will now need a little attention or that possibly—if the car has been used a long time—the linings will need replacing.

Spring Joints and Other Parts.

Spring joints and connections, bearings for brake levers and gear shift levers, steering knuckles and spindles, and other parts that receive lubrication through means of the oil can take in more or less dust and become gummed so as to prevent perfect lubrication. These parts should be cleaned, also with a brush and gasolene, several times in a season. New oil should be forced into and around all such joints with an oil gun, so as to be certain every spot is reached. Care should be taken to see that any surplus oil is wiped off, as otherwise it will only attract dust and cause further wear of the parts.

Universal Joints.

The treatment accorded other wearing parts of a motor car should be given the universal joints, as without good lubrication of these parts much power will be lost and considerable wear occasioned.

Cleaning Outside of Motor, Transmission, etc.—After each trip in the country, or every hard drive, and surely once a week if the car is used practically all the time, the motor and transmission should receive a thorough cleaning. A small pail of gasolene and a medium-sized paint brush should be used for the purpose, as the brush will be found exceedingly convenient in getting around all the parts. Begin at the top, as the gasolene in running down will tend to loosen and carry off any dirt it reaches. The cleaned parts will have a better appearance if wiped off with a cloth. This work should never be attempted inside a building. It is dangerous to use even an electric light in this work, as if the bulb should be struck and broken the gasolene would immediately ignite and in all likelihood the car would burn even if life were not sacrificed. Above all, do not attempt to start the motor, or turn on the switch until assured that all gasolene has evaporated. Be sure that dirt is kept out of the pan under the motor, as this will hold gasolene. Push the car away from the spot where cleaned, so the gasolene that has soaked into the ground will not catch fire.

Cleaning Tires.

Not infrequently oil will pass through the rear axle housing and spatter on the tires; or if the chains on a double side chain car receive too much oil it will find its way to the tires. Oil will soon disintegrate rubber; it will at least make soft spots wherever it is permitted to remain. If oil does find its way to the tires it should be removed instanter. This may be accomplished by rubbing a cloth saturated with gasolene over the parts and immediately following by rubbing this dry with a clean, dry cloth. The gasolene must not be permitted to stand an instant, for otherwise it will play havoc with the rubber. Chalk rubbed on the tires will remove some of the oil and will not hurt the tires.

Body Washing.

A car should never be washed while exposed to the rays of the sun. A hose, plenty of clean water, a sponge, chamois skin, soft brush and a green soap especially made for washing cars are the requisites. Run water on all parts of the car (except inside), beginning at the top, so as to soften the mud or dirt. The stream should be large but with little force, as too much pressure will tend to carry the grit across the varnish and leave scratches. The green soap should be mixed with water in a pail and should be applied with a clean sponge, at the same time keeping on a stream of water to carry off the soap and anything that is disturbed from the surface of the body. After this operation the clean water and clean sponge should be passed over the car again. The running gear will likely have more or less grease on it. A little gasolene in a pail of water and applied with a soft brush that will reach all cracks and obscure parts will take off most of this oil. The green soap should follow the gasolene-water operation, but with a sponge that is NOT used for the body. After a thorough rinsing the body should be wiped dry with a wet and wrung-dry chamois. The chamois should frequently be rinsed in clean water and wrung out. Rubbing with the chamois should be lengthwise of the car always and the chamois should be

shaken out frequently to prevent it from becoming hard and harsh.

Do not use gasolene on the body unless it is to take off a little grease; then use it sparingly and as quickly as possible.

No matter what is told you, DO NOT use any sort of wood polish on a body. The best body finishers strongly advise against this, notwithstanding the fact that there are hundreds of polishes "absolutely guaranteed" to make the car look like new. Once or twice a season, if the car has been subjected to trying trips in mud, it will be wise to take off the body so as to remove all dirt from inaccessible places.

Cleaning and Dressing Tops.

Motor car tops should be kept up in order to preclude the possibility of their cracking and to retain their shape. They may be washed the same as the car, but should be wiped as dry as possible and after thoroughly dry should be given a dressing of neatsfoot oil.

Cleaning Upholstery.

Ordinarily upholstery can be cleaned with a dry cloth, but a dampened sponge will not injure it if rubbed with a dry cloth before the moisture has had opportunity to soak in. After the upholstery has been cleaned it will be greatly improved if given a dressing made from the whites of eggs beaten.

Cleanliness—In order to facilitate keeping a car clean—and cleanliness is necessary from every standpoint of utility and comfort—it is important to secure, as far as possible, surface smoothness in design—the absence of unnecessary roughness in the shape of projections, leather buttons, straps, clamping-pieces, moldings, levers, ornaments, etc. Many autoists of large experience favor the simplest lines of car-body design and the tabooing of all adornment or special features which increase wind resistance and secrete dust.

Cleanliness of Lamps—This is not only essential to getting the best light from a lamp, but eventually to keeping the lamp alight at all. For oil lamps the air holes must be kept clear

of charred and oily wick. The crust from the top of the wick should be wiped off on extinguishing, and while the burner is warm. For acetylene lamps the washing out of all the slaked lime residue in the generator is necessary, and should not be omitted.

It will not be found that brass lamps are more troublesome to keep clean than nickel plate; in all cases metal polish is useful in brightening up. If the trouble of keeping brass parts bright becomes unendurable they can be bronzed.

Cleanliness of Machinery—This is a great difficulty, unless it is systematically attended to after every run, and requires more labor and care than is generally bestowed on it. A splendid move toward clean engines has been made by the introduction of the undershield, a metal plate right under the entire machine. Unfortunately, the usual position of the radiator results in dusty air being drawn on to the engine, except in the most modern cars.

Clearance—In an engine the distance between the piston and the cylinder-cover when the piston is at the end of its stroke; the amount of the free play between the related parts of any machine; the free play or space between the cogs of two geared wheels when fitted together; the amount of space by which the frame of an automobile clears the ground or any obstacle.

Clevis—In machinery, an iron shaped like the Letter U or a horseshoe, etc., with ends perforated to receive a pin—used as a connection for rods, etc.

Click—A pivoted device which moves backward and forward so as to engage the teeth of a ratchet-wheel or rack; used either for holding the ratchet-wheel in a position to which it has been moved by other parts or for moving it forward. Also called a pawl.

Clinch—The part of a nail, staple, etc., turned over and hammered back to secure it in position: the head or edge of a clincher tire. Also written Clench.

Clincher Rim—A rim for automobile wheels, having the edge

turned in to form channels in which flanges on either side of the tire casing may fit snugly.

Clip—A metal clasp used to connect the springs of a carriage-gear.

Clip, Spring—A metal clasp which operates by means of a spring to hold the sides or jaws together.

Clogged Tubes—The condition of tubes when there is an obstruction in the water or gasolene pipes, due to the introduction or formation of some foreign matter.

In heavy oil engines the tubes in connection with the vaporizer become clogged by a carbonic deposit unless kept clean.

In steam cars the water tubes become clogged by a deposit of lime and salts when water containing such is largely used. See Repairs and Adjustments.

Clogged Vaporizing Tubes—When a steam car using a flash type of boiler is running badly and showing steam, it is an indication that the fire is not in a good condition; therefore, wet steam is being put through the engine. The chief reason for the burner failing to give a good fire is that the vaporizing tubes are not cleaned often enough. As a result, the carbonic deposit from the oil accumulates to such an extent that only a small quantity of the fuel is served to the burners. Sufficient heat, therefore, is not generated to convert into steam the amount of water delivered to the generator by pumps. If the oil vaporizing tubes are kept clean and free, the pump glands screwed up sufficiently tight to prevent leakage, but not tight enough to cause any undue friction on the plungers, the car will run at its best, so far as the generator and its attendant parts are concerned.

Clothing—One of the greatest risks entailed in motoring is the danger of catching cold, due to the fact that at high speed the wind will penetrate all ordinary clothing materials. The best safeguard is to wear leather in some form or other. Complete leather garments are not essential, neither are they healthy, owing to the fact that they confine the body's ex-

halations. It is really only the front portion of the trunk that requires special protection, and therefore a waistcoat with leather front is sufficient for summer. This waistcoat should have closely-fitting sleeves, and the back should be of woolen material.

Of course an overcoat should be carried also, in case of extreme cold or rain, and it should be made to lap over the chest for greater protection, and also to prevent the rain from driving in. It is sometimes found advisable to line the portion covering the chest with kid or light leather. The coat should also be long and full at the bottom, so as to sit over the knees comfortably.

One great trouble encountered when automobiling in open cars in wet weather is due to the fact that the water lies on the cushions. To prevent this, a waterproof apron which buttons at the side can be used. The driver can then sit in the wet without suffering any hurt. An excellent makeshift can be made out of a sheet of waterproof cloth, long enough to wind once and a half round the person and hooked at the side. There will then be no joint behind to admit the wet, and the driver will sit on a double thickness.

Many beginners and some motorists, old enough to know better, go to extremes in the matter of clothing and often render themselves ridiculous thereby. The clothing trade in recent years has catered especially to the requirements and the whims of automobiling enthusiasts and the result is that special garments and articles of wear for all manner of purposes and in all manner of styles now fill the market. Many are meritorious and some are even becoming to the male figure and the female form divine.

A well-known writer on motoring treats the matter thus:

"Special clothes are not absolutely necessary for enjoyable motoring; neither is it necessary that special motor clothes should be hideous. In due time, doubtless, the budding motorist will get over his vanity and be content to appear as rational on his car as off it. But, unless some equally irrational legislators have their way, the fact will remain that motoring

is, to all intents and purposes, sitting still in a wind averaging about thirty miles per hour. Nothing makes one feel the cold like a wind (except hunger), and in order to keep warm it is necessary to prevent the wind penetrating one's garments. While the clothes should not confine the movements of the body, there should be nothing to flap about. This applies more particularly to capes, soft brimmed hats, and anything that can abscure the driver's vision, whether worn by himself or by anyone near him. His own handkerchief and his companion's furbelows may be equally responsible for a bad accident, by being blown for a moment across his eyes. Warmth should not be sought in mere bulk, for a heavy garment is tiring to wear, even though one do not walk about in it. For the sake of appearance, the cut and color should be as unobtrusive as possible; indeed, the color should be rather governed by the liability, or otherwise, to show up dust and grease stains than by anything else.

"For the most part an ordinary business suit will do very well; it is the outer garments that demand most consideration. Shiny black leather is no longer 'the thing,' and tan leather is not much better. But the windproof quality of leather may be availed of in the form of a tan leather waistcoat, or, perhaps better still, a detachable breastplate of the same material. As one is always facing the wind, the leather need only cover the front, the woolen back being left free for exhalation purposes. If a leather waistcoat be chosen, it may be provided with leather sleeves, lined with silk.

"Overcoat Design—The overcoat is the piece de resistance. It is the sort of thing upon which one acquires ideas of one's own. The following is a common-sense type: A dark waterproof cloth, cut double-breasted, and with a serviceable turn-up collar, with tab to button across the throat. Straps to the sleeves, so that they can be folded and secured around the wrists. Lined with chamois leather throughout, and the sleeves lined again with Italian cloth to prevent the leather clinging in putting the coat on. A second lining of wool would be an improvement in warmth; and as to water-proof qualities

it is useless to expect too much. The penetrating powers of rain are greatly accentuated by the speed of the car, and leather itself will let the wet through in the course of a long drive. There is then nothing for it but oilskins or india-rubber.

"The skirt of the overcoat should be cut much fuller than for walking, so that there may be ample material to cover the legs when seated. The motoring tailors have various dodges in the way of concealed folds, which let out automatically when wanted in this way. The cuffs can be fitted with short false linings gathered into elastic bands to stop the draught up the sleeves; but a cuff folded and held by a strap fits into the gauntlet of the glove better. For very cold weather nothing is so good as a fur-lined coat. A fur-lined coat is better than a coat with the fur outside, as it is less cumbersome and less pretentious.

"As to the headgear, nothing sticks on better than a well fitted cloth or leather cap; and if this be provided with a shield that can be turned down to cover the ears and neck in bad weather, it will serve for all ordinary occasions.

"For warmth, mitts are to be preferred to gloves; the fingers keep each other warm better when all are ensconced in one compartment. The gauntlets may be in one with the gloves, when the latter will have no fastenings. If the gauntlets are separate (and they last much longer than one pair of gloves, as a rule), the wrists of the gloves should be contracted with rubber, or should be made of a knitted material which will contract on its own account. The gauntlets should be so stiff that they will not pucker into folds around the wrist. Here, again, fur is capital for warmth, and rubber for keeping out the wet. Never drive far in the rain without gloves if the wet coat sleeve rests on the wrist, as the cloth edge may soon chafe a sore wound.

"It should be understood that these hints refer in the main to clothing suitable for open cars. With a wind shield and a hood no rubber or mackintosh coats are necessary as the combination of screen and hood keeps out all the worst of the

weather. At the same time it is as well to have a light mackintosh on the car, so that if one has to alight on the open road in the rain one can do so without getting the driving coat sodden with wet.

"Leather gaiters form an excellent protection for the legs. They should extend well over the boot uppers, and the extensions, if any, should be flexible, to allow of freedom in walking; if too stiff, they and the instep will war against each other with almost certain damage to both. Warm footwear is essential in cold weather.

"In view of possible roadside repairs, a suit of overalls should be carried on the car. Do not hesitate to use them. One can work much more freely with them on, and so save time, as well as the cost of a new suit in the end. The kind in which the trousers and jacket are cut as a single garment is the handiest. A big apron with bib is better than nothing. Remember that gasolene and ammonia are capital for removing grease and acid stains respectively from the clothes.

"Ladies (as well as men) should wear small hats when motoring as too much topsail is apt to induce headache. And head and hat together should be enveloped in some sort of veil to keep the hat on and the dust off. For the rest, we must leave the fair sex to utilize the intuitive judgment with which they are so liberally endowed."

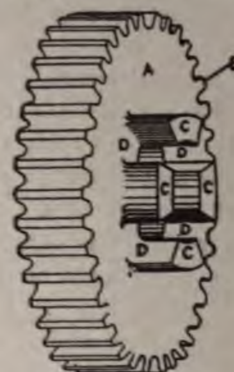
Clutch—A movable coupling device for connecting two shafts in the same plane, so as to run independently or together. One shaft may be stationary until connected with the revolving one, whereupon the two take up the motion and act as one shaft. Connection can be broken at any time, and thus one portion remains stationary, while the other keeps up the motion.

In motor cars a clutch is usually interposed between the engine shaft and the transmission system, of which, in fact, it may be said to form part. It is also used in many gear systems in order to obtain a direct drive on one speed, or to secure a loose pinion on to a drum or box fixed on a shaft.

Clutch systems may be divided into two broad classes—Positive and Frictional.

Positive Clutches.

These may be again subdivided into one-way clutches, such as a ratchet-wheel and pawl, or the type in which the jamming roller is employed, similar to those adopted in the generality of free wheel bicycle hubs, etc.; and dog clutches, in



DOG CLUTCH.
A, Gear wheel.
B, Gear teeth.
C, C, C, C, Male portion of dog clutch.
D, D, D, D, Female portion of dog clutch.

which square-jawed projections fit into suitably shaped hollows formed in the female portion of the clutch.

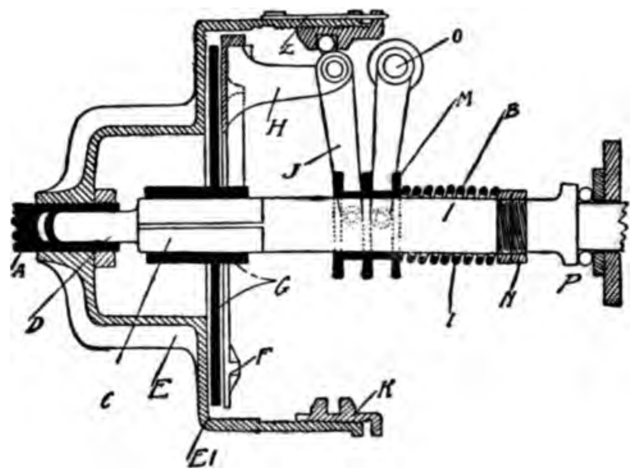
Friction Clutches.

As the name implies, the friction clutch is the type wherein the connection between the two parts to be rotated is supplied by means of friction. This type of clutch is the one most extensively adopted in automobile work, and many different forms are in use.

The Conical Clutch—The most common type is the conical clutch in which a coned member, generally formed by the flywheel of the motor, receives the male portion of the clutch attached to the driven shaft, the face of the male portion being

often covered with leather. This part of the clutch can be slid in and out of contact with the female part and is normally held up to its work by a powerful spring. The more modern type has the advantage that it does not introduce any end thrust on either shaft except when out of engagement.

Plate or Disk Clutches—These are of comparatively recent introduction, and have some most important advantages over the coned variety. These advantages are briefly as follows: There is no fiber, leather, or other organic substance to wear away. The clutch can run in lubricant which precludes any



Simple Form of Plate or Disk Clutch.

possibility of seizing or getting hot. It can be so adjusted as to take up the load gradually. There is little possibility of its being applied so suddenly as to cause undue strain to the gears, engine, or tires. The amount of pressure required to release it is also very small, and it can be most easily controlled so as to slip a little or not at all, just as required by the driver. The wearing parts also, that is, the faces against which the frictional contact is made, are not so likely to wear as the engaging surfaces of cone clutches, and what little they do wear will hardly be enough to upset the adjustment, while it is well known that in the cases of cone clutches with leather

faces, a little wear will require a great deal of adjustment—endways—to take up the amount which the clutch moves endways before it becomes really engaged.

A very simple form of disk clutch is shown in the illustration. It is fitted to some English cars and has been found to give excellent results. It runs in a bath of oil, so that there is no danger of any of the parts becoming dry or seizing.

The action of this clutch when disengaged is as follows: The engine in revolving turns the bell-shaped casting E. The friction plate G remains stationary on the square of the shaft B, and lies idle between the two plates E1 and F; meanwhile the oil is surging around between all three plates. On the clutch pedal being released the spring I forces along the grooved sleeve M, carrying with the latter the ends of the three levers J. These force the plate F to the left, and plate G is then firmly gripped between the plates F and E, thus transmitting the power to shaft B through the medium of the squared part C. The oil is squeezed out from between the four adjoining surfaces, and gradually the plate G begins to revolve, eventually being locked fast to the other two plates.

It will be seen that the action is quite gradual, and that however quickly the clutch is let in the film of oil between the plates will prevent its picking up the load suddenly. The absolutely flat surfaces and the great pressure applied to them, owing to the leverage gained by the long lever J with its fulcrum so near one end, insure a rigid contact between all the plates; and the shaft B, which transmits the motion to the gear box, turns as if one solid piece with the engine crank case. It will be seen that only the very slightest movement is necessary to engage and disengage the clutch. The thickness of two pieces of paper is sufficient distance between the plates to put the clutch out of action.

In the illustration, besides the parts already mentioned, A is the engine crankshaft, D a pin-bearing on the end of shaft B inside end of engine shaft A. H is one of three brackets on plate F to which the lever J is attached. K is a screwed ring in the end of the bell-shaped casting E, which can be

screwed in and out and determines the normal position of the three friction plates. When the adjustment is made the ring is locked by a locking spring L screwed to the bell-shaped casting. N is a lock-nut, by which the tension on the spring can be adjusted. O is a lever operated by the pedal and which disengages the clutch. P is the ball thrust bearing which takes the thrust set up by the pressure of the spring I.

The Multiple Disk Clutch—Another type of clutch which has been very largely adopted is the multiple disk, in which there are a large number of thin disks capable of moving laterally so as to come into frictional engagement with each other, but alternately anchored, as far as circumferential movement goes, to one or other of the clutch members. In some cases the disks are corrugated, forming practically V clutches; in others they are quite flat.

The Combined Disk and Cone Type—A combination of the disk and cone clutch has proved very simple and "sweet" in action. It consists of a series of thin steel plates of V section arranged in a flywheel. The one set is in frictional contact with the other, and together they transmit the motion from the flywheel to the driven shaft. The sets of plates are kept in contact with each other by the pressure of springs acting on a bearing plate.

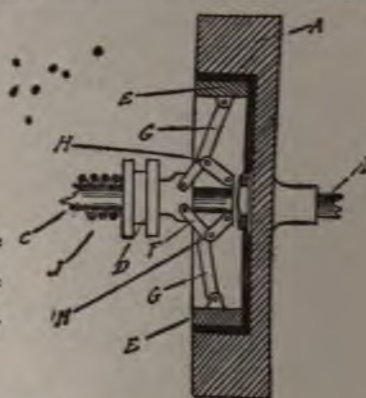
In this clutch there are four friction plates which drive the gear-box shaft and five friction plates which are driven by the engine flywheel. There are thus sixteen friction surfaces, so that the strength of the springs need only be very slight. This particular clutch is designed to permit a great amount of slip without causing damage, but in the ordinary course of driving the clutch should not be allowed to slip unnecessarily, as to do so persistently causes excessive wear on the plate.

Expanding Clutches—These clutches are very effective and generally get over the difficulty of end thrust which is repellant to the mechanical mind. It may almost be admitted that the primary object when designing the expanding clutch was to get over the end thrust difficulty.

A simple form of expanding clutch is shown in the illustration.

Usually the engine flywheel runs free of the clutch altogether, that is when the clutch is out of gear. When the clutch is put into gear the spring J pushes up the sliding sleeve D expanding the toggle joints H, H. These force out the segments E, E of the inner clutch member into intimate contact with the inner face of the flywheel rim. The toggle joints increase the leverage as the clutch is forced further into contact and only a light pressure on the spring J is necessary. It will also be seen that all end pressure set up

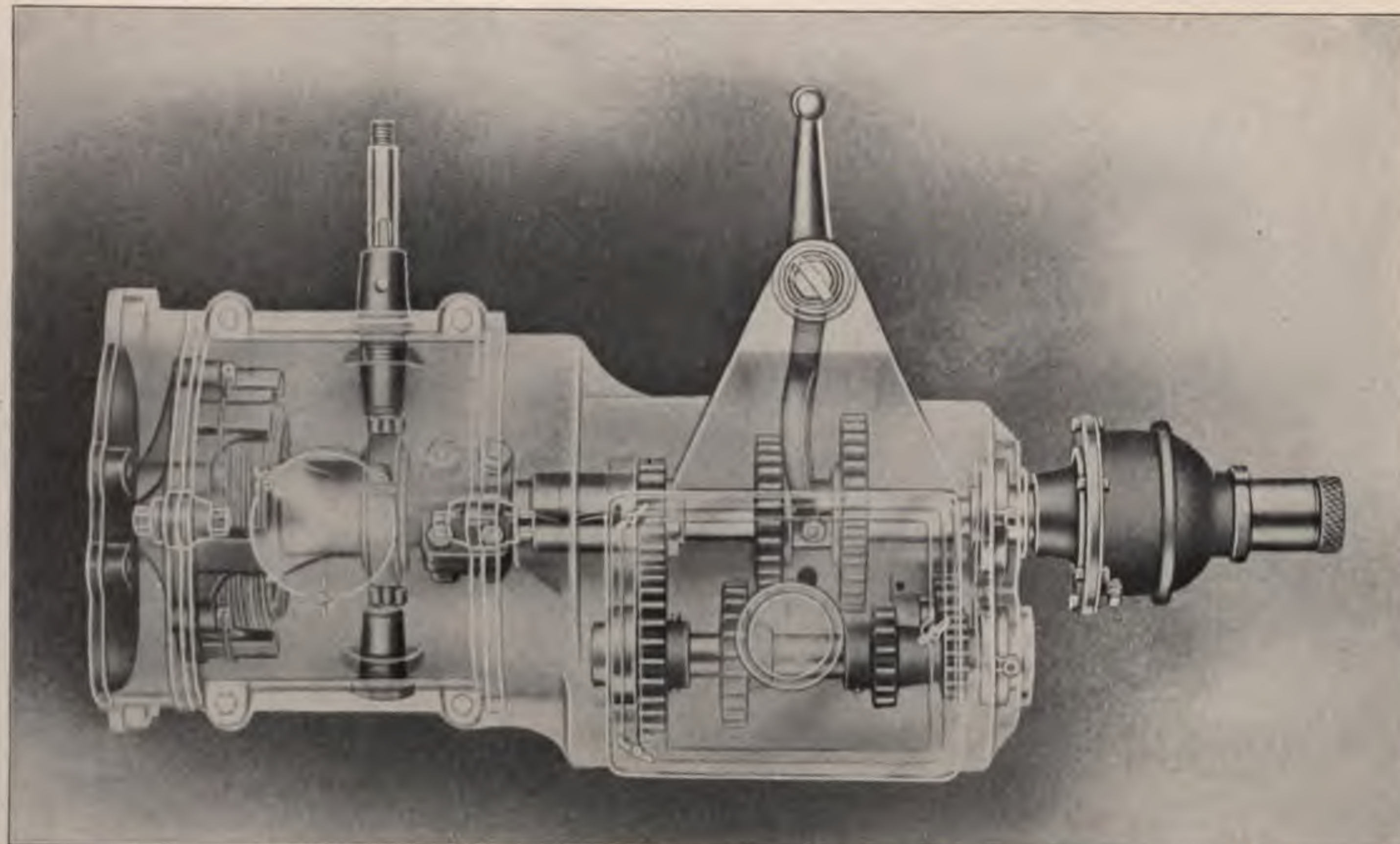
A, Engine flywheel.
B, Engine crankshaft.
C, Gear shaft.
D, Sliding sleeve on gearshaft.
E, E, Segments expanding inside friction ring.
F, F & G, G, Link levers of the toggle joints H.
H, H. Toggle joints which force the clutch segments into contact.
J, Spring which keeps clutch in engagement.



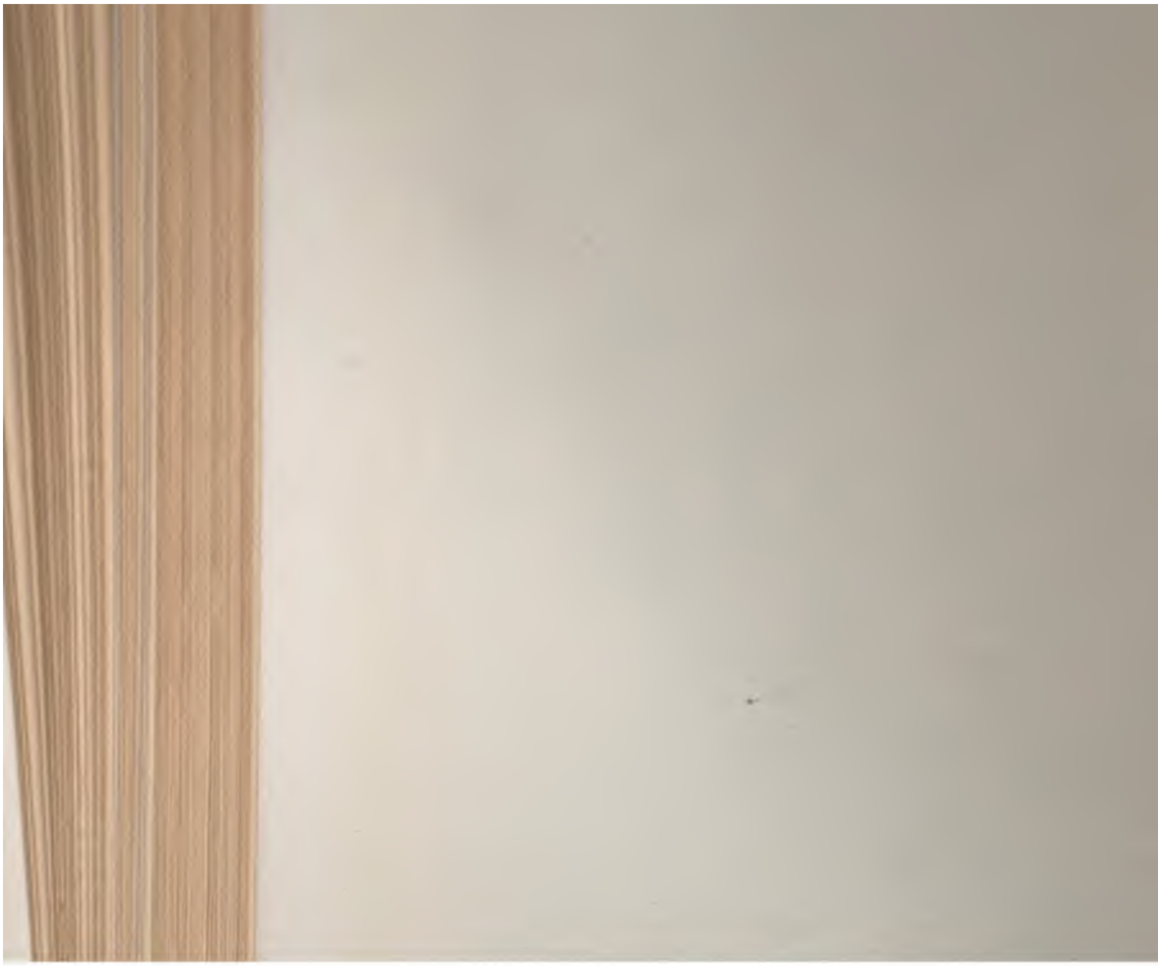
Simple Form of Expanding Clutch.

by the spring is self-contained on the gear shaft C, and does not have to be transmitted through any bearing. This form of clutch, therefore, is absolutely free of end thrust, both when the clutch is in engagement and when it is running free. It is practically the only type in which this great advantage is obtainable.

In the De Dion expanding clutch the expanding segments are forced out by right and left handed screws operated by a central sliding cylindrical rack. This is now only used on one small type of these cars, to operate two speed gears, two clutches being used, one to each gear. Up to 1904 this system of clutch was in use on all types.



Stevens-Duryea Clutch and Transmission—Skeleton View.



Rim or Contracting Clutches—These, unlike the expanding clutch type, grip the outer periphery of the constantly rotating member, instead of the inner circumference, just as a brake-band grips its drum.

Coil Clutches are not much used but there have been some notable examples of their use, as in the Mercedes cars, etc.

In coil clutches the gripping action is obtained from the automatic tightening action of a spring steel coil upon the inside of a parallel or the outside of a conical steel drum. Where the coned drum is used, the longitudinal springing properties of the coil are employed to press the steel convolutions into contact with the driver, and where the parallel driver is used the gripping is initially obtained by the tendency of the spring to unwind itself and so expand.

Electrical Clutches—Of these the Belgian Auto-Mixte is perhaps the best known. It comprises an arrangement whereby, by altering the quantity of current passing through the clutch coils any desired amount of slip can be obtained without the great friction usually entailed. This clutch is said to give most excellent results.

The Clutch in Hill Climbing.

Many drivers resort to the slipping of the clutch to enable the car to surmount a hill rather than change to a lower gear. There are many who advocate such a method of driving, while, on the other hand, there are those who deprecate it. Without doubt, it may be said that the practice is a bad one on a long hill when the engine begins to flag early, but if it will obviate changing for just the last few yards over the crest of a rise there is nothing against the practice, except the slight extra wear on the clutch, which can be ignored when the clutch is properly designed and made. As some are not acquainted with this method of driving, we give the modus operandi of surmounting a hill by slipping the clutch. The object of the change-speed gear, of course, is to maintain as near as possible an equal engine speed, but it will be easily seen that when one is driving up a hill and the engine begins

to lag, the clutch may momentarily be withdrawn, the engine allowed to pick up its speed, and the clutch gently let in again, when the momentum will be kept on the car for a short distance. Then the engine will begin to flag again, necessitating another brief release from the heavier portion of its work, after which it will again pick up the car. As a matter of fact, one has to keep one's toe on the clutch pedal all the time, and be prepared to let the engine pick up, though exerting some of its power in the propulsion of the car while the clutch is slipping. Many autoists have long used this method of surmounting the crest of hills rather than change speed for a matter of a few yards, and have not experienced any ill effects from it; especially when the clutch leather was kept in the best possible order and the adjustment maintained.

The novice, when he attempts this action, invariably makes the mistake of making the withdrawal of the clutch too deliberate, and thereby often fails in achieving the desired result. Those who have so failed should heed the following advice: Keep the heel down on the floor board, and keep tapping the pedal with the toe with a rapid but not too powerful stroke. This is much better than continued pressure.

Renewal of Clutch Leather.

If you find it necessary to take the gear-box down it would be as well to see that the clutch leather is in good condition, and if it shows signs of burning or is worn thin this opportunity of replacing the leather should be taken. With a little care in removing the rivets and taking off the old leather, it can be kept intact, and will be useful to mark out the new one, which should be cut from the thick part of the hide, and will not cost much. Be careful to countersink the holes for rivet heads, so that they sink well below the surface of the leather, and put it on rough side out. It will be better trued up in the lathe, but if carefully and truly fitted it may do without, and if soaked with castor oil will very soon accommodate itself to the female portion after the car has been run a few miles.

Attention to Fierce Clutches.

The comfort and safety of the driver and the efficiency of the car depend upon the clutch to a very much greater extent than is generally supposed by the average motorist. A fierce clutch takes up its work too quickly, causing the car to jump forward with a bound upon starting, instead of moving off gradually, in fact almost imperceptibly, at first. It is very obvious that the fierce clutch must put unusual strains upon the whole of the vehicle. It certainly does not impress the passengers when they are shot up in their seats and by the time they comfortably settle themselves find the car traveling at about twenty miles an hour. This is particularly the case if it be their first experience of automobiling. On the other hand, with a properly graduated clutch the work is taken up by degrees, all excessive strains are eliminated, and the passengers cannot help admiring the ease with which the car is started.

A fierce clutch is often caused by the clutch-spring being too strong, and this causes an unusual amount of power to be applied to the clutch pedal in actuating the clutch, and it is apt, particularly at critical moments, to stick, preventing its being as rapidly withdrawn as it should be, thereby needlessly increasing what risks there are attached to the driving of the car. These risks are very few indeed and it is a great pity to make trouble for oneself where it need not exist.

There are two certain remedies for a fierce clutch. One is to ease the tension of the clutch-spring, the other is to cleanse the clutch leather thoroughly by means of gasolene and apply a small quantity of castor, or neatsfoot oil to the surface of the leather. This keeps it in a pliable condition, and permits of its slipping sufficiently when taking up its load, and yet holding it when driving with a full load on.

If an ordinary leather-faced cone clutch is found to be too fierce, although carefully dressed with proper oil (which, by the way, possesses the double properties of causing a clutch both to hold and slip), the leather should be raised at four or six opposed points, and a thin disk of copper, slipped down

about half-way of the cone between the leather and the metal, and the leather again secured. The effect of these four or six disks is to raise very slight projections or bosses in the leather, which bosses, upon clutching, take up the drive first with a continually decreasing amount of slip until the whole surface of the cone is engaged.

Other remedies are: The application of neatsfoot oil; the treatment of the leather with castor oil, followed twelve hours later by a tablespoonful of kerosene; and the use of a mixture of castor oil and commercial glycerine. This must be well shaken up and then applied thinly and evenly.

Slipping Clutches.

A slipping clutch, on the other hand, is a source of constant annoyance to the driver, as much of the power developed by the engine is wasted by the clutch slipping instead of its transmitting the power to the road wheels for purposes of propulsion. It will usually be found that the cause of abnormal slipping lies in the fact that the clutch is in such a position as to take up a lot of the oil which is ejected from the crank chamber of the engine or the gear-case. If such is the case, the first thing is to find the course pursued by the oil, and to check it by means of a baffle-plate composed of a piece of tin, or if it should be leaking through the bearing one can usually manage to wrap about the shaft a few turns of ordinary worsted yarn, which will prove an effective stop to the oil excretions. Provided that the slipping is not due to over-lubrication, it may be found that the clutch-spring is too weak, and it is, of course, necessary to tension the spring up just sufficiently for it to transmit its full power and no more.

Drivers who suffer from weak ankles are particularly addicted to slacking the clutch-spring back, as in the course of a long day's run they suffer no small amount of physical pain if the clutch is at all fierce, while the time may come when the prompt withdrawal of the clutch may avert an accident. It should be borne in mind that if a clutch is allowed to go on slipping the leather will soon be charred and perhaps ruined.

Clutch Troubles.

In not a few cars the engine flywheel is secured to the engine crankshaft by means of a tapered end into which is sunk a key, the flywheel being held up on to the tapered end by means of a nut and lock-nut. Beyond the flywheel lock-nuts the crankshaft is continued as a small diameter spindle, over which the clutch-spring is placed, this being retained and adjusted by means of nuts on the end of the aforementioned spindle. In assembling a clutch of this design, it is very necessary in the first place well to grease the spring, and to be perfectly certain that the spring abuts firmly against the male part of the clutch, and not against the flywheel lock-nuts. Should the spring take the latter position when the clutch is withdrawn, a turning action is put on to the nuts, tending to unscrew them. When the nuts are slacked back sufficiently to permit the flywheel to move, it is not very long before the key becomes damaged sufficiently to admit of a large amount of movement to the flywheel, the result of which is, in all probability, a spoilt crankshaft.

Mud on the Clutch Leather—A most important thing in wet weather is to keep the clutch free from mud, as this, if it once gets into the leather is very difficult to get rid of and is a very dirty job. Indeed, when this happens, one is very apt to feel inclined to tighten up the clutch until it gets grip. Needless to say, this is a dangerous proceeding. The best thing to do is to wash the leather with gasolene by means of an ordinary paintbrush, which, by the way, is a useful thing to carry about in the car, as it comes in handily for many purposes. Fuller's earth, powdered ordinary chalk (not the French variety), or lime, should be used to dry up the clutch leather.

Leather Clutch Rivets a Source of Trouble—The usual method employed to fix the leather to the metal center of a clutch is to rivet it up by means of a number of copper rivets, whose heads are countersunk into the leather. If the rivet heads are not knocked in lower than the outer surface of the leather, then when the clutch is let in these grip fiercely on

the metal outer clutch surface, and thus prevent the clutch working smoothly and gradually getting up way on the car. Some difficulty may also be experienced in taking out the clutch, owing to the seizing of the copper rivet heads on to the metal clutch. As it is rather difficult to obtain leather suitable for clutch work of any greater uniform thickness than a quarter of an inch, and some of this must be turned off in truing up the leather after riveting, there does not remain more than an effective depth of one-eighth of an inch of leather held by the rivet head, and this should be one-sixteenth of an inch below the leather outer surface, to allow for wear and compression. Those who experience trouble with fierce clutches should examine the rivets, and knock them lower if level with the leather outer surface.

Interconnected Clutch and Brakes.

On a number of motor vehicles the foot brake lever and also the hand brake lever are connected to the clutch, so that on operating the foot brake or the hand brake the clutch is taken out of action. It is claimed that such a method is best for the novice, but some good authorities are inclined to doubt that such is really the case. It seems to them that with the flexible engines now fitted very little operation of the brakes should be required, as the whole control of the car, save in cases of extreme emergency, can be readily brought about by the operation of the throttle valve. A motorist who through his own fault has quickly to apply foot and hand brakes is one who should not drive a car, as evidently his judgment or his ability is at fault. For instance, on descending long, steep hills the car can be held under control in most cases quite readily by almost closing the throttle and retarding the spark, but oftentimes perhaps too great a speed will be attained by using the throttle and ignition solely. In such cases a slight application of the foot brake or the hand brake gives the extra check required; but if the application of one or other of these brakes disconnects the engine, one really good brake is gone, and the car immediately gets way on if the

brakes are not in absolutely good order. It will be seen that by dispensing with the inter-connections which can be readily done on many of the cars now fitted with them, a really valuable and additional brake from the engine is obtained. One really good point in favor of the hand-applied brake taking out the clutch is that it is impossible to start off from rest with the hand brake on, simply because the clutch cannot be let in at all without the brake is taken off.

Driving "On the Clutch."

In the earlier days of motoring, when engines would refuse to run slowly on half-throttle and used to stop dead as soon as the speed of rotation reached a moderate figure, say 300 revolutions a minute, many drivers used to "drive on the clutch" to avoid gear changes. To a small extent this is quite permissible, and does no harm, but if this facility be used to excess the violent and continual rubbing will not only wear out but will also overheat and burn the clutch leather. A well selected and well adjusted modern 4-cylinder car, of say 20 H. P., will, by a movement of the throttle alone, run from four miles an hour to thirty-five miles an hour on its top gear, so that there is little excuse nowadays for driving persistently "on the clutch." It is worth mentioning that driving "on the clutch" is wasteful of fuel, and tends to boil the radiator water.

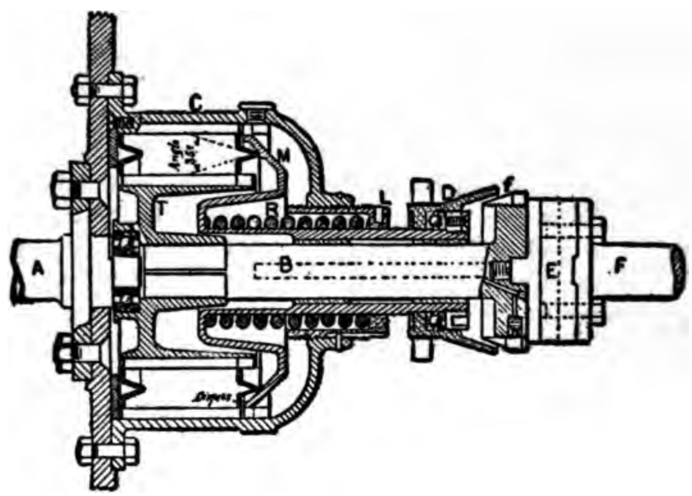
Many clutches are put into action by a spring, which may be tightened by turning a nut, or a group of nuts and this provision for taking up wear is a valuable one, provided the nuts are reasonably accessible, which is by no means a universal provision. In other cases the spring action can only be increased by inserting a new spring; as all springs are liable to unexpected breakage, a spare clutch spring should be carried when on tour.

The Hele-Shaw Clutch.

A modification of the multi-disk clutch in which the cone and the disk are combined is the Hele-Shaw clutch, a diagram of which is shown herewith. It comprises a set or "pack" of disks and there is a V-shaped circular impression struck up in the

end disk. The figure shows the V shape of the disks; in fact, the whole clutch is well shown here in section. The female cone D bears on the male cone "f" when the clutch is thrown out, thereby checking the spinning tendency of this clutch, or, if the viscosity of the oil is heavy, holding it quiet during the changing of gears by the motor car driver.

In place of the entire surface of the disks bearing, only the V portions engage. This clutch is copiously lubricated, and the V, or engaging portions of the disks, are perforated with holes so that the oil may circulate quickly in and out of the



The Hele-Shaw Clutch.

V grooves as they are engaged and disengaged. Outside the V portions of these plates or disks there is a comparatively large space between them, permitting the free circulation of oil and consequent rapid carrying away of heat if the clutch slips much in the operation.

The number of plates in the multi-disk clutch is made to vary with the power transmitted, the diameters remaining the same within certain limits. The principle involved is that the thickness of the pack of plates shall not exceed the diameter of the plate. When this becomes necessary in order to trans-

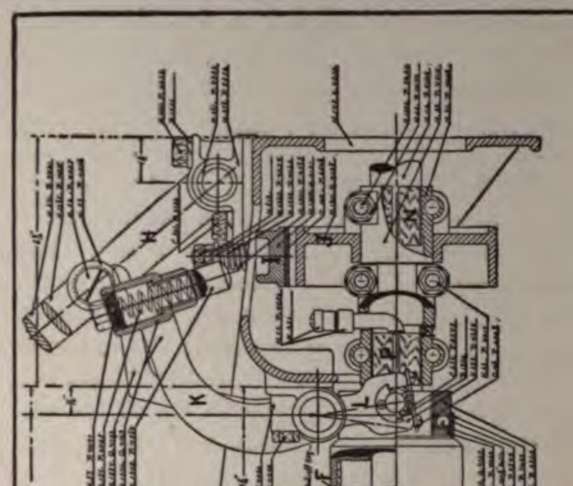
mit a load, the plates are increased in diameter, fewer of them being used. The clutch is necessarily heavy, but this is partially offset by the relatively small diameter. It has, consequently, little spinning tendency.

A Typical Three-Plate Clutch.

The clutch fitted to the Knox Model "O" 38 H. P. car is typical of modern construction. See full-page illustration.

This clutch is of the three-plate type with cork inserts. The flywheel and clutch consist of four members; the flywheel proper, C; flywheel cover, G; spring plate, D, and the cork insert driving plate, E. This clutch is shown in the engaged position, the cork insert plate being tightly clamped between the spring plate and flywheel cover by the 16 clutch springs shown recessed in the flywheel rim. Each of these springs presses against the plate with a 60-pound pressure, giving a total pressure of practically 1,000 pounds to transmit the power of the motor through the gear set to the road wheels. This 1,000 pound spring pressure against the clutch plate is so reduced by the disengaging levers that a 25 pound pressure by the operator's foot on the clutch lever H releases the clutch and allows the gears to be shifted or the clutch to be slipped.

The disengaging action is as follows: the clutch lever being pushed downward, the sliding clutch collar F is pressed inward on the hub of the clutch cover G by means of the forked lever L and its connecting levers. This action is communicated to the spring plate D by the four clutch levers A and the disengaging pins B and adjusting screws O. As soon as the spring plate is pressed inward the cork insert plate E is freed of its spring pressure, and if the motor is in motion this plate will slowly stop revolving. To further the stoppage of this plate quickly, allowing the gears to be shifted noiselessly, a clutch shaft brake is provided. By referring to the cut, lever K is securely fastened to the clutch shaft and operates with it. At the instant the clutch plate is completely released this lever presses downward, striking the clutch brake shoe I and forcing this shoe by spring pressure only against



the brake drum J, thus stopping quickly the clutch shaft P and transmission shaft N, to which the brake drum is bolted.

This Knox clutch is designed to be run practically dry, the designers claiming that with the use of cork inserts they can eliminate the use of an oil bath. The lubricating points are small oilers on the end of the clutch shaft P and on the sliding clutch collar F.

The Sturtevant Automatic Clutch.

The following description of the Sturtevant automatic clutch, as used on the Automatic automobile (see photographic illustration) will be found of interest to all motor-car owners:

"If an automatic clutch is applied to any gasolene automobile, that car can be controlled by throttle exactly like a steam vehicle, and have the same wide variation of speeds, from zero to full power, on all drives, and whatever engine is used. The clutch requires no attention whatever; it grips of itself gently, but with ample power at exactly the right time and never fails to let go promptly when release is desirable. The engine cannot be stalled; therefore the car cannot run away down hill backwards, even if the brakes refuse to act, because the car can be held anywhere by the motor when the throttle is pressed (the little throttle lever usually placed on the steering wheel).

"Slip—It will be shown that an automatic multiple-disk clutch is more durable than any other; that it can be permitted to slip without loss of efficiency, and to slip as long as required, suffering no harm whatever, and never requiring any adjustment (and without practical wear), nor any attention at any time. It will also be shown that at such times as slip is not desirable slip becomes an absolute impossibility.

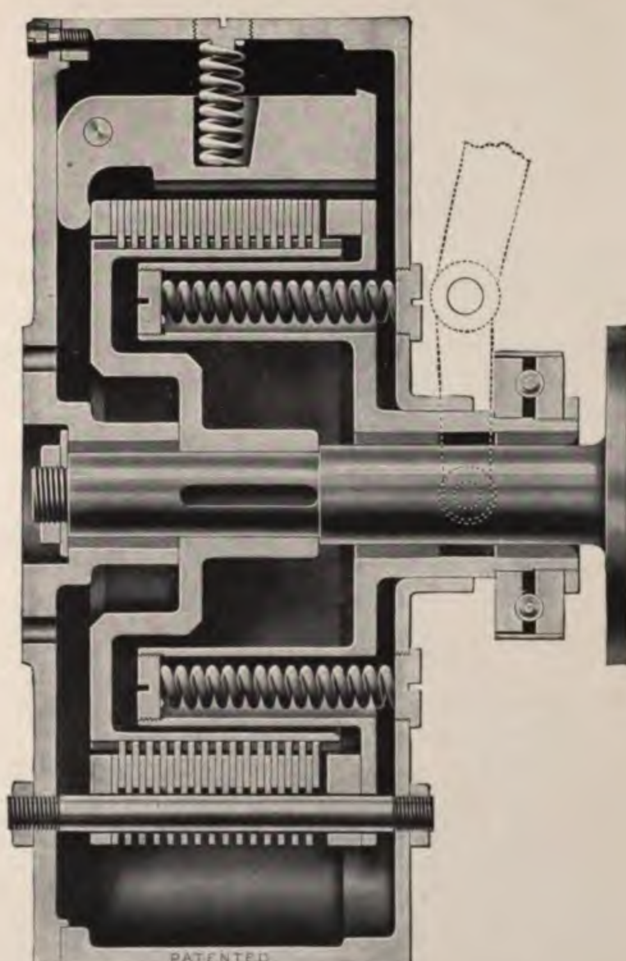
"Description—This automatic centrifugal clutch placed in the hollow oil-containing flywheel of any motor has cast-iron multiple disks of the usual type, but they are encircled by lever weights exactly like the governor weights of a steam

engine. These give the necessary momentum to the encl ing flywheel shell, which consequently is not heavier tl usual.

"Each lever weight (exactly as in a governor) is held by a spring, and until engine rotations force the weights o ward the clutch runs free. But when the weights do mo out, by the centrifugal force generated by quicker rotatio the weight fingers gradually pinch the clutch disks togeth and thus cause smooth grip; and when revolutions dimini and lessen, centrifugal force permits the springs to pu back the weights, their fingers gradually let go, and the gine is free. This is all. But the strength developed in th fingers by centrifugal action is astonishing.

"Efficiency of Automatic Slip—When common clutches slipped to produce lowest car movements the motor m retain such considerable speed as will insure against stalli Therefore the loss of its efficiency by slip is a serious cons eration. But the slip of an automatic clutch (which c never occur until the motor has reached the lowest speed which it can be trusted to run) is of negligible importanc because if with equal slip, one motor runs at twice the rev lutions of another, the faster engine has only one-half t efficiency of the slower.

"Wear—How Prevented—Centrifugal multiple-disk clutch suffer no practical wear, because when they slip the mot has been throttled to run at its lowest dependable speed, an the weight fingers only squeeze lightly together the oily disk which cannot then rub together destructively. The secret centrifugal multiple-disk clutch construction is, first, to kno at what pressure disk plates turning on each other at slo surface speed can endure continuous slip without harm, an then add enough disk plates to hold the whole power of th motor at this pressure. It is plain that under these conditio slip is absolutely impossible at higher speeds; and harmf slip is not possible at lessened revolutions. When the clutches turn faster, the disks are positively locked, becau centrifugal force increases as the square of rotations, and in



Clutch, Flywheel and Driving Shaft to Gear—
The Automatic Automobile.

The Automatic Automobile.

mense grip pressures are quickly available when motor speed is accelerated.

"In brief: Slow engine speed is the only thing that can produce automatic clutch slip; ana because the pressures are then lightest, and the disk surfaces rubbing slowly in oil, slip does no harm. These designs produce smooth starting, and sure holding at the lowest speeds at which the engine is sure to run.

"At all speeds above this, the clutch holds with much more power than is needed. All other clutches slip, not when the engine is slow, but when it is going fast, and exerting too much power for the clutch. In all other clutches that do not securely hold the engine, the frictional parts rub together when they slip at high speed, and with destructive pressures. Since centrifugal disks, when they slip, rub lightly, and turn slowly, it would be strange indeed if they did not surpass all other frictional clutches in durability."

The Warner Constrictor Clutch.

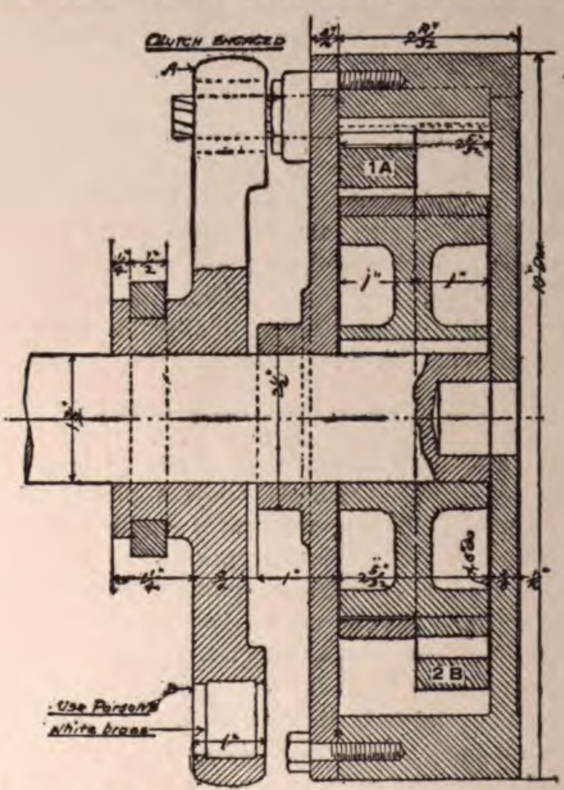
A recent innovation in motor car clutches is the Waıner Constrictor clutch, of which we show a photographic view and also a section. Its construction is simple and strong. It consists of two or more crucible spring steel rings or bands which are forced into frictional contact with the polished surface of a chilled iron drum by rods or "plungers" which bear on the knuckles of the toggles, and tighten the rings around the drum one after the other, giving the clutch great flexibility. The clutch is inclosed in a dust proof case and runs in an oil bath. The wear, which is very slight, occurs on the steel rings (the drum being as hard as glass) and can be taken up in a moment by a turn of the compensating screws.

The following are instructions for adjusting the Warner 2-ring high-speed clutch:

"When the clutch is properly installed and connected, fill it with heavy oil, loosen both set screws on the sides of the clutch case, and throw the shifter 'in.'

"Begin tightening up the set screw for the ring next to the flywheel (marked 2B on the diagram) until you can move the machine 'light' with the 2B ring alone. Then set the jam nut to hold the set screw in that position.

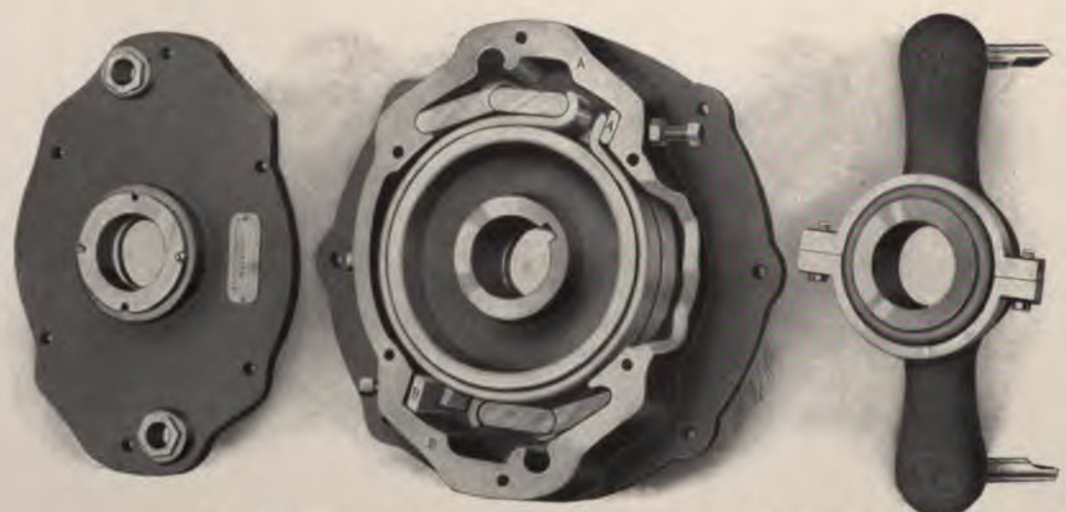
"Then throw the clutch out part way until the 2B ring is



The Warner Constrictor Clutch—Plan.

disengaged, and tighten up the other set screw until you can move the machine as before, by means of the 1A ring acting alone. Then set the jam nut.

"You have now a crude adjustment and can run the machine, without any feed or load, the A ring taking hold first and starting the machine, and the B ring following it; but

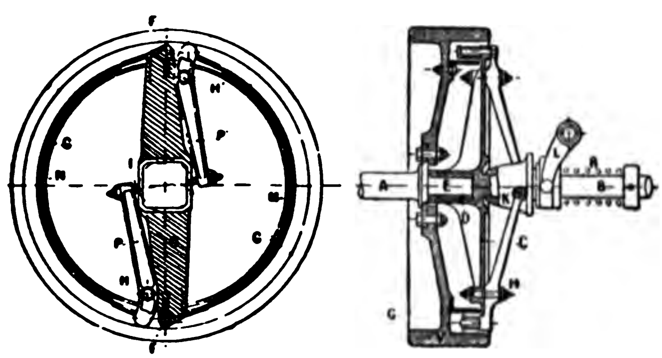


The Warner Constrictor Clutch. (See page 341.)

the two rings together will probably slip, owing to the loose adjustment. If so, tighten the screws up alternately, a little at a time, until the clutch will transmit the full power needed. Be careful not to set the clutch too tight. It should slip for a few seconds before the driving and driven portions of the machinery travel at the same speed. The clutch may need tightening up several times for the first few days, but thereafter will need no further adjustment for a long time."

The 4-ring Warner low-speed clutch is adjusted in the same manner, beginning with the set screw nearest the flywheel.

The Mors Clutch—This is a type of metal-to-metal clutch on the contraction principle. It consists of a drum attached



The Mors Clutch.

A, Engine shaft
B, Primary gear shaft.
C, Crosspiece keyed to B.
D, Bush upon which crosspiece revolves.
E, Extension of crank shaft A for carrying the bush D and crosspiece C.
F, F_1, Pins to which bands are attached.
G, Drum on to which band contracts.
H, H_1, Pins to which levers P, P_1 are attached.
I, Studs bearing on sliding cone.
K, Sliding cone
L, Clutch lever.
M, N. Two halves of band.
P, P_1, Levers operating band.
V, Flywheel.

to the rear face of the flywheel and on to which a steel band contracts, the two becoming locked when the force contracting the band reaches a certain point.

Materials for Clutches.

The materials for disk clutches in general have been various; namely, steel on steel, steel on leather-faced disks, steel

on bronze and steel disks with cork inserts. Regarding the use of the latter a well-known engineer writes: "I have recently been informed of a disk clutch with cork inserts of natural cork that wore out in about 1,000 miles twice in succession. This same clutch was equipped with compressed cork inserts, which have driven the car some 5,000 or 6,000 miles without perceptible wear."

Steel disks against steel have sometimes become badly heated and cut to such an extent as to make the clutches inoperative. Steel against bronze, however, does not seem to cut in this manner and the wear after two years' steady use is only 0.002 inch or 0.0003 inch at the outside edge of the disks.

Steel and aluminum enter largely into the construction of the most modern clutches and fiber is often used instead of leather as a covering for cone clutches. The fiber is sometimes interwoven with copper threads and springs are sometimes inserted beneath the fiber to prevent jerky movements of the car when the clutch is first engaged. It is claimed that this form of clutch insures smooth engagement and that the fiber covering is not affected by oil or water like a covering of leather.

Clutch Adjustment—See under Change Speed Gear.

Clutch, Bayonet—A form of clutch armed with prongs which act on the ends or lugs of a friction-strap, fitted on the wheel to be driven.

Clutch, Coil—A clutch in which the gripping action arises from the automatic tightening action of a spring steel coil upon the inside of a parallel or the outside of a conical steel drum.

Clutch, Cone—A type of clutch in which a coned member receives the male portion of the clutch attached to the driven shaft.

Clutch, Crab—Same as Jaw Clutch.

Clutch, Disk—See Plate or Disk Clutches, under Clutch above.

Clutch, Dog—An ordinary toothed clutch, operating by the engagement of toothed wheels or bands.

Clutch, Expanding—See under Clutch above.

Clutch, Friction—A device for conveying motion from one line of shafting to another by the frictional contact of cones, expanding toggles, etc.

Clutch, Jaw—A toothed clutch in which square-jawed projections engage suitably shaped hollows in the female member.

Clutch-pedal—See Pedals.

Clutch, Rim—See Rim or Contracting Clutches, under Clutch above.

Clutch-spring—A spring which operates to engage a clutch, as by holding friction members together.

Clutch Stop—A stop, generally a spring pad, and sometimes in the form of a little cone clutch, against which the male member of the clutch on being disengaged comes in contact. It is used to stop the spinning of the clutch member when it is taken out of engagement with the engine, and to slow it down, thus allowing of an easier change to a high gear. See Driving.

Clutch, Use of the—See under Driving.

Clutch, Withdrawing the—See under Driving.

Coach Work—See Carriage Work.

Coasting, Braking and Reverse—See under Driving.

Coasting Slopes or Grades—See under Driving.

Cobalt—A metal resembling nickel in its general characteristics, ductility, tenacity, etc. It can be used like nickel for coating iron. Recent discoveries of the metal in Canada have added largely to the world's supply and cobalt is becoming increasingly useful in the arts and manufactures.

Cock—A tap or faucet containing a valve for permitting or arresting the flow of liquids through a pipe, etc.

Cock, Blow-off—A device for removing water from the

boiler of a steam-engine. It is a faucet in the and when opened causes the water and sedime out by the steam.

Cock, Compression—A cock or tap with a which collapses when pressed by the end of wound by the key, thus preventing the flow of motor engines a cock for testing the compres

Cock, Drain—A small cock at the lower end for letting off water of condensation.

Cock, Gauge—A stopcock which indicates water in a boiler, etc.

Cock, Grease—A faucet or valve in the lubr of a motor car.

Cock, Mud—A cock used to draw off the mu from a steam-boiler.

Cock, Pet—A small plug-cock, usually of a s fit into a thread from one-eighth to three-eigh tap size. Used for draining off water conden cylinders; also in water circulation systems. pit-cock.

Cock, Plug—A cock having a plug with a tr fitted into a transverse hole in a hollow barre The diameter of the plug being greater than diameter of the cylinder, it permits liquid to flo latter only when the transverse hole in the plu as to form a continuous passage with the hollo inder.

Cock, Relief—A cock fitted on a gasolene mo part of the compression.

Cock, Stop—A faucet having a stop or valv close a pipe for gas, water, etc.

Cock, Try—A gauge cock; one of a set of thr used in combination to indicate the height o steam-boiler.

Cock, Waste—A cock for drawing off waste water; a drain cock.

Coefficient—That which unites in action with something else to produce a given effect; a number or known quantity used as a multiplier.

Cog—The tooth or cam of a gear-wheel by which it is connected in motion with another wheel or part of a machine; any projection in machinery that moves another part by sliding and pressure.

A disk having a number of teeth or cogs cut across its edge is known as a cog-wheel, gear-wheel, spur-wheel or pinion. See Wheels, Gear or Gearing.

Cog-wheel—See Cog above.

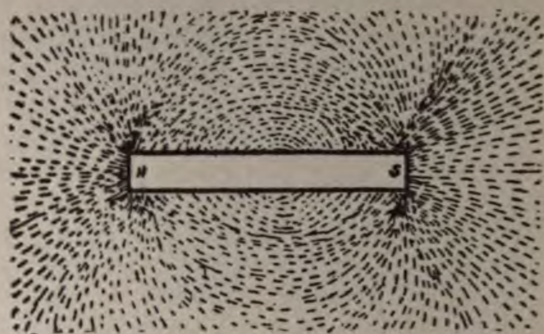
Coil—In the sense commonly employed by automobilists the term coil applies to the induction coil, the apparatus used for supplying the electric spark which ignites the cylinder charge.

The induction coil was originally invented, in something like its present form, by Ruhmkorff, but before entering into any details, it is necessary to explain the fundamental principles upon which the action of the apparatus is based, since it is impossible to explain or to understand the complete device unless these vital points are thoroughly grasped by the reader.

The automobilist who is hazy on the subject, and to whom theoretical electricity is untrodden ground, will do well to perform on his own account a few simple experiments, in order that he may comprehensively follow the function of every component part of the apparatus to his own satisfaction.

First, get a small magnet, a bar magnet preferably, but if this is unobtainable a horseshoe shape will do. Fix this magnet up in a recess in a board so that it lies flush with the surface, and lay a sheet of plain thin white paper on the top of the board, covering the magnet. Now scatter some fine iron filings on the top of the paper and tap the edge of the paper gently with a pencil or the finger, just sufficiently to

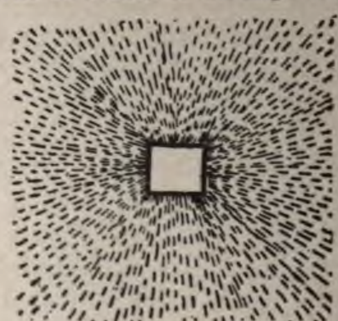
make the filings vibrate on the paper. Suppose a bar magnet to have been used, the filings will arrange themselves along



Lines of Magnetic Force in Horizontal Position.

regular lines in a curved fashion between the poles of the magnet.

Now push the magnet endways through a piece of paper, so that the paper forms a ledge of considerable width all around the magnet and at right angles to it. Repeat the scattering of the filings, and again tap the paper as before. This time the filings will be found to arrange themselves in radial



Lines of Magnetic Force in Vertical Position.

lines around the magnet, all pointing to the center. If a horseshoe magnet is employed for the experiments, circles will be found round both poles of the magnet, but congested and distorted in the space between them.

Now, let us consider what these lines indicate and prove. In order that the definite arrangement of the filings could be arrived at, it is evident that there must have been some power or force to cause such arrangement, and that this force followed the direction indicated by the filings. What happens is this: The action of a magnet, as is generally known, converts a piece of iron into a magnet, too, which is easily demonstrated by picking up a nail on a magnet and observing that the first nail will pick up a second. The magnet under consideration converts the multitude of iron filings sifted over the paper into as many little magnets, which set themselves into the positions to which they are compelled by the big magnet. The first experiment showed, therefore, that the force exerted by the magnet acted along the lines of filings obtained, the filings naturally lying along the lines in a direction coincident with the lines along which the magnetic force acted, whilst the second experiment with the single pole showed that the force emanated radially from the magnetic center.

Now, if these lines are examined they will be seen to travel in curves between the poles of the magnet in the first experiment, and these curves gradually become of such radius that they are discontinuous, and apparently proceed into space. If the combination of the two visible results obtained be considered, it will be seen that the magnet is inclosed, as it were, in a cage of these lines traveling from one pole to another.

The filings, however, are only used to make the direction of the lines visible, and to prove their existence, and, of course, there is in reality only an invisible envelope about the magnet within which an invisible force acts upon certain substances, but it has been proved that this invisible force is due to waves in the ether that space is conjectured to be full of. The term applied to the space in which the magnetic action is potent is "the field of force," and the field is supposed to be composed of myriads of "lines of force." For convenience in terminology, the first is usually spoken of as the field of the magnet.

Now, we will go a step further, and here the reader will be barred from making his own experiments, unless he has access to delicate electrical apparatus. Faraday found that if he took a coil of wire with a closed circuit (that is to say, one end connected to the other—endless) and a magnet, and he inserted the magnet sharply into the space comprising the center of the coil, an electric current was caused to flow in the coil so long as the motion of the magnet continued, and that a second current was produced, but in the opposite direction, when the magnet was withdrawn. The currents are very small, and a delicate galvanometer is necessary for their detection, but the discovery paved the way for the whole of the modern electro-dynamic machinery and induced current apparatus in use. Identical results were obtained when the coil was moved over a magnet.

We have now got a fact giving a certain amount of relationship between magnetism and electricity, namely, that motion of a magnetic field (surrounding the magnet) in the neighborhood of a coil of wire causes an electric current to pass in the wire. It was also found that a coil of wire was itself a powerful magnet when an electric current was caused to flow through it, and that as a magnet it possessed a magnetic field. Of course, each single strand of wire comprising the coil is in itself a magnet, and surrounded by its own field, so that the field of a coil may be considered to be a combination of smaller fields, and it can easily be seen that the greater the number of these small fields the more powerful their combination will be in its magnetic effect. Obviously the simplest way to increase the small fields is to increase the number of sections, or turns of wire, in the coil. The same thing applies to the coil providing the induced current.

If only a single section or turn of wire formed the coil, the current induced and the voltage of the current would be infinitesimal, but the greater the number of the turns the greater the voltage of the current produced.

Principle and Construction.

The current is produced on account of the formation of a magnetic field surrounding the wire and the section of lines of force, so that in order that the maximum power of the induced current may be attained, it is essential that the maximum number of lines of force must be cut within the active magnetic field.

One more point: The magnetic action of the coil is found to be greatly enhanced by winding it upon a soft iron core, due to the fact that this expedient collects the lines of force from the coil, as it were, and prevents them spreading further. It utilizes the lines passing through the space inside the coil, which would otherwise be useless, by absorbing them and becoming a magnet with a field of its own, thus strengthening that radiating from the coil. Both a coil of wire and soft iron, however, have the property of losing their magnetic conditions almost instantaneously directly the magnetizing influence is removed, and obviously their field of force, which is, however, as rapidly regained.

If, therefore, a coil of wire wound on a magnetic core be imagined to have the magnetizing electric current rapidly passed and interrupted, the reader will form an idea of the magnetic lines of force suddenly enveloping the coil to their fullest extent, and as suddenly vanishing again like a bladder alternately distended and allowed to collapse completely. Now, then, if this first coil be imagined as surrounded by another having a large number of turns of wire, and so arranged that the greater part of the magnetic field of the first passes through it, it will be seen that, directly the current flows in the first coil, and the field of force from it springs up, this springing up or distention of the force will cause immense numbers of lines of force to cut the numerous sections of wire as the motion proceeds, with the result that an electric current is "induced" to flow in the secondary coil, and that this continues till the magnetic field of the first coil is stationary. Directly the current ceases to flow in the first coil, the magnetic field in vanishing cuts the coils of the sec-

ond winding again and a current is induced, but which flows in an opposite direction to the first.

Thus it will be seen that the making and breaking of a continuous current in the central coil induces an "alternating current" in the outside winding.

This is precisely what happens in an induction coil, which consists essentially of a central coil of wire wound upon an iron core, called the primary winding; a second coil, consisting of very many turns of fine wire; an automatic switch for rapidly making and breaking the current supplied to the central coil, and an apparatus known as the condenser.

The engraving, Fig. 1, shows the arrangement of a hypothetical coil, so dissected that the internal parts named above can be seen.

The center A is a circular bundle of very soft iron wires bound together and inserted in a tube, with both ends flat and projecting from either end of the tube slightly.

B is the primary winding, and is indicated by the single spiral thick black line, though of course it consists of many turns of wire in reality. The wire with which the primary coil is wound is of a good thickness and well insulated, so as to permit of a considerable flow of current at low voltage through it.

C is the secondary wire, denoted by the fine black spiral line, and this again is only shown as a single coil for the sake of simplicity. The secondary winding comprises many thousand turns of very fine insulated wire, wound in a series of layers, each layer being carefully insulated from the next the object in obtaining so many convolutions of wire being to provide a large number of sections to be cut by the fluctuating lines of force from the central or primary coil, for, as we have seen, the greater the number of coils to be cut by these lines of force, the higher the voltage of the induced current will be, and a high voltage means a powerful spark between the points of the ignition plug.

D1 is the trembler blade of the contact breaker, which consists of a soft iron disk D attached to a flat spring, which is

fixed at its other end to the insulated terminal E. This blade or spring is free to vibrate therefore with E as its fixed point. Half-way along its length, the blade D1 carries a little disk of platinum O1, and this platinum is exactly opposite to, and in contact with, a platinum pointed screw. The platinum point is seen at O. This screw is insulated by means of the bridge F, which forms its nut, and whose feet (not seen in the figure) form terminals for the connections to it.

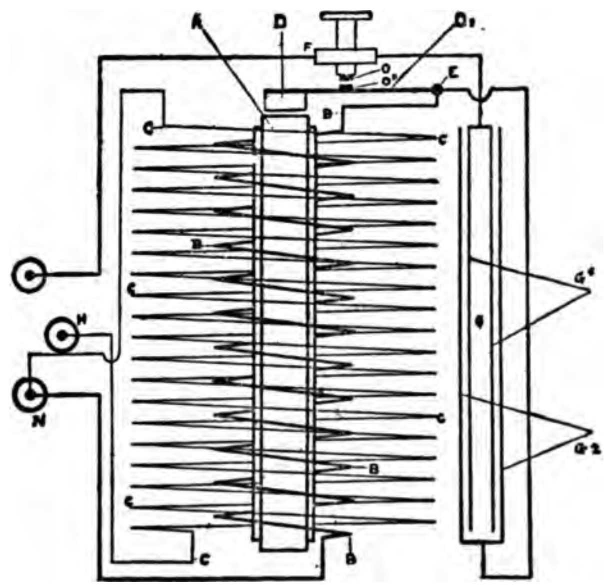


Fig. 1.—Diagram of Coil Construction, Showing Windings, Connections and Condensers.

G is a condenser, and G1 and G2 are the separate series of elements. This condenser is made of a series of sheets of tinfoil, insulated from each other by means of paper soaked in paraffin wax. The method of manufacture is somewhat as follows:

The sheets of tinfoil are cut into the form of rectangles, but smaller than the sheets of paper, so as to leave a border all round each metal sheet. One side of the rectangle is,

however, left with a tag on it in the shape of a ribbon, and in building up the condenser a sheet of paper is first laid, then a sheet of tinfoil, but placed this time so that the tag projects from the opposite end of the paper. This method is continued throughout the whole assembling of the condenser, and it is not hard to see that by this arrangement every alternate sheet of tinfoil has its tag at the same end. These tags are all connected together at either end, and wired for connection to their correct terminals.

Action of the Condenser.

The precise action of the condenser is too involved to fully explain it here, but its function generally and its particular necessity in connection with an induction coil must be stated. A condenser is essentially an apparatus for the temporary storage of current, which it is capable of refurnishing again instantaneously, its precise relation to, and the necessity for its presence among the component parts of an induction coil being as follows:

When the flow of the current is broken in the primary coil, the converging lines of force cause a strong current to flow in the secondary coil, and, as we have already seen, a coil with a current flowing through it is itself a magnet and has a separate field of force of its own. The current induced in the secondary winding is, however, itself momentary, and as this current dies away together with its field, the returning lines of force, cutting the coils of the primary winding, cause in their turn an induced current to flow in the primary coil. and the condenser is fitted in order to absorb this induced current, and to give it out again to help the current from the batteries in remagnetizing the iron core of the primary winding. The condenser also reduces the sparking at the platinum points when contact is broken, taking the induced charge, and preventing a flash, which would be produced if the circuit was broken entirely.

The three small black circles represent the terminals of the coil. P is the positive terminal, to which the positive